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Tectonophysics

S150 Plate Tectonics
OPHIOLITE EMPLACEMENT BY COLLISION BETWEEN THE SOLA PLATFORM AND THE KULANSU ISLAND ARC, INDONESIA
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The emplacement of the large Kulansuan ophiolite belt results from a Miocene collision between the Kulansuf Island arc and the Sola platform, a continental fragment. Seafloor and onshore geophysical and geological study show that the Sula platform is overthrust by the ophiolite from sedimentary rocks deformed along the leading edge of the platform. The ophiolite represents the southern edge of the Cretaceous basin, which has been uplifted by oblique collision against the platform. The ophiolite is composed of harzburgite on the SE Arm and passes upward through a complex of gabbros and diabase dikes to the East Arm. Ophiolite outcrops underlies the harzburgites on the SE Arm, beneath low angle thrust contacts where seen. The outcrop is composed of thrust packets of both red shale and turbiditic matrix sandstone and has a moderate south to northeast dipping foliation, of regionally representative strike. This fabric is consistent with a southward component of movement of the platform along the Kulansuf margin. The regional structural pattern in the ophiolite is to thrust over younger or Neogene and Paleogene sedimentary rocks to the east and south) but under the ophiolite belt to the west. The Cretaceous basin may represent an older forearc basin, and the ophiolite is an uplifted part of its basement. Deformation of the ophiolite may have occurred in part on the sea floor prior to emplacement, but no fast fabric of the deformation occurred during emplacement. The Kulansuf ophiolite is only one of a number of such bodies in the Indonesian region, each of which has a very different origin and tectonic history. (Ophiolite, melange, forearc solitaire, metlez geophysics).
J. Geophys. Res., Bed, Paper 3B1160

S150 Plate Tectonics
COLLISION, ROTATION, AND THE INITIATION OF SUBDUCTION IN THE EVOLUTION OF KULANSU, INDONESIA
E. A. Silver (North Kulansu Board, University of California, Santa Cruz, California, 95064), R. McCaffrey and S. Stevens

The Island of Kulansuf, Indonesia, has been shaped and deformed as a result of collision with the Sula platform, a sliver of continental material from the northern margin of Australia-New Guinea. The collision has resulted in rotation of the north volcanic arm of Kulansuf and the initiation of the convergent wedge of the North Kulansuf Trench. The North Kulansuf Trench changes laterally from a zone of active deformation in the eastern part to a wide accretionary wedge to the west. Early stages of thrusting produced a steep frontal slope (8-10°), indicative of relatively high basal shear stress, whereas the more advanced (western) zone of thrusting produced a gentle (2°) slope, consistent with low basal shear stress. Reported paleomagnetic data suggest post late Miocene counterclockwise rotation of the North Arm with respect to the Celebes Basin about the eastern end of the arm. Convergence between the North Kulansu Arm and SE Kulansuf is documented by the presence of the Tofu thrust, its outcrop is strongly curved and its accretionary wedge-series in width from a minimum of a few km or each end to a maximum of 20-30 km in the central part. The northern and termination to the Lofrenkuf Norman Fault, with a reported offset of 20 km.

S150 Plate tectonics
EARTHQUAKES, PLATE SUBDUCTION, AND STRESS REVERSALS IN THE EASTERN ALEUTIAN ARC
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Plate subduction beneath the 1,500 km long segment of the eastern Aleutian arc between Kodiak and the Islands (156°W and 176°W longitude) is studied with observations from teleseismic data. The primary data base consists of hypocenters of earthquakes (Ms≥ the period 1965 to 1975), carefully selected from the Bulletin of the International Seismological Centre, and of 64 new local mechanism solutions.

The principal results of this study are: hypocenters of intermediate-depth earthquakes in the eastern Aleutians appear to define a weakly developed double seismic zone at depths between 70 and 170 km. Additional evidence for a double seismic zone at coast from focal mechanisms which generally show down-dip dilatational stress for earthquakes in the upper zone and down-dip directed stress in the lower zone. Major features of the double zone can be explained by thermoelastic stresses in the downgoing plate. The observed predominant down-dip stress polarity at intermediate depths in the descending plate reverses along strike of the arc. This stress reversal coincides in map view with a change from a continental to an oceanic arc. The collision may result from spatial differences either in the coupling between the plates at shallow depths or in the rheology of the surrounding - mostly oceanic continental - mantle. Alternatively, the stress reversal may be related to the time since the last great earthquake. If the observed stress polarity relates to the elapsed time since the last great earthquake it may be a significant observation for long- to intermediate-term prediction of great thrust earthquake in subduction zones. Portions of the eastern Aleutian arc in map relief show prominent gaps that appear to have a high probability for great earthquakes in the next few decades.

A moderate-sized bathymetric feature in the Pacific plate, the Amlia Fracture Zone, modifies subduction and produces a bend or offset in the downgoing plate, as well as an offset in the line of active volcanoes in the upper plate. Subduction of the fracture zone appears to aid the formation of summit basins on the arc platform and some anomalous behavior of a 100-km long segment of the main thrust zone. (Aleutians, earthquakes, mechanisms, stress reversal, subduction).
J. Geophys. Res., Bed, Paper 3B1213

S190 Tectonophysics (instruments and techniques)
LOCALIZED SEISMOMAGNETIC FIELD CHANGES NEAR ACTIVE FAULTS IN CALIFORNIA 1974-1980
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Daily averages of magnetic difference fields, for the years 1974-1980, between 23 magnetometers on the San Andreas fault (between San Francisco and the Mexican border) have been analyzed to fnvolve the geomagnetic variation of rrec(al orlgth and to test if it is

In 10 (with epicenter. Also stations within 30 km the 1979 Coyote earthquake undergo localized tilt change up to a year before that event. It is therefore, these variations are on a broader scale of temporal scale than those for the Parkfield earthquake during the period 1974-1980, the geomagnetic values in approximately uniform across the area, with no development of any significant anomalies. This is roughly consistent with the 1965.7-1978.7 secular v in nearly all of California. It is followed by a marked increase in regional secular variation. The same coherence between anomalous variation is different at time to not occur, rather than the epicenter before the Parkfield earthquake, suggesting the local field variation occurs on a scale of 10s the 10 km.

Conclusions: tectonomagnetic events are not limited the times of the Parkfield and Coyote earthquakes but satellite data suggest that observable events are a repeatable. If the observed changes are due to geom they indicate that changes of seismic strain energy different by larger than geologic strain rates.
(Tectonomagnetism, California)
J. Geophys. Res., Bed, Paper 3B1065

Erosion of U.S. Shorelines

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We have assembled data on the rate of change of the U.S. shorelines, including those of the Great Lakes. Obtained from geologists and engineers, our data base covers 1689 sites. The national average (unweighted) shoreline erosion rate is 0.40 m/yr. Along the Atlantic coast the average rate of recession is 0.8 m/yr; the Gulf coast is 1.8 m/yr; and the Pacific coast rate, including Alaska, is 0.005 m/yr. Statistics for Delaware Bay, Chesapeake Bay, and the Great Lakes are also summarized.

Introduction

The River and Harbor Act of 1968 issued a mandate to the U.S. Army Corps of Engineers to compile an inventory of the nation's coastlines, including the Great Lakes. The final summary, "A Report on the National Shoreline Study," indicates that of the nation's 84,240 miles of coastline, 20,500 miles could be categorized as "seriously eroding" at the time the study was initiated [*U.S. Army Corps of Engineers* (USACE), 1971]. Nine regional reports provide specific information and proposals for corrective measures.

In evaluating the National Shoreline Study, the General Accounting Office determined that lack of adequate funding and personnel and inconsistencies in methodology and assessment criteria prevented the study from satisfying any but the broadest requirements of the mandate [*U.S. General Accounting Office*, 1975]. However, to date, the National Shoreline Study has remained the only comprehensive assessment of coastal conditions on a nationwide scale.

In 1979 we reported on rates of shoreline erosion of the mid-Atlantic coast from New Jersey to North Carolina [*Dolan et al.*, 1979]. Since then, under sponsorship of the U.S. Geological Survey, we have assembled data on shoreline changes for the remainder of the United States, including Chesapeake Bay, the Great Lakes, and Alaska. The information is designed for presentation as a series of U.S. Geological Survey maps drafted at a 1:2,000,000 scale, as a 1:7,500,000 scale map in a *National Atlas* format. The assembled data bank of shoreline rates of change is accessible in a computerized Coastal Erosion Information System (CEIS) at the University of Virginia. We are currently analyzing coastal hazards and are developing statistical evaluations of vulnerability to coastal processes. These data are included in CEIS and are detailed in a separate map series. We will discuss coastal hazards in a subsequent report. In this paper we present a summary of the differences in erosion rates for various geographic regions of the United States.

Mechanisms for Shoreline Change

Shorelines recede when the forces of erosion exceed the amount of sediment supplied to the coast. The greater the deficiency of sand, or the higher the wave energy, the more rapid the rate of erosion. Any of three factors (energy, sediment supply, or sea level) can vary through time and change the balance.

Sediment Transport

Three principal classes of sand movement are responsible for most changes occurring on beaches and barrier islands: (1) movement along the shore when waves approaching the coast at an angle set up sediment transporting processes called longshore currents; (2) movement across the shore during periods of high waves and tides when water levels may be elevated to the point that the beach is overwashed; and (3) movement of sediment by wind action.

All beaches and barrier islands respond to these dominant processes; there are, however, significant regional differences [*Fisher*, 1968; *Godfrey et al.*, 1979]. In the northeast, for example, overwash occurs less frequently, and large dunes and cliffs have formed from sediment eroded from glacial deposits, while along the mid-Atlantic coast, where tide ranges are lower, overwash is a more common process.

Storms

Hurricanes are responsible for extensive

mid-latitudes. Each year, between 30 and 40 such storms generate potentially damaging surges and waves. The Lincoln's Birthday storm of February 12, 1973, for example, caused severe beach erosion along the coast from Long Island, New York, to Miami, Florida, and the Ash Wednesday storm of March 7, 1962, produced waves over 10 m high, damaging millions of dollars of property along the mid-Atlantic coast [*Cooperman and Rusendal*, 1962]. Similarly, a series of extratropical storms in December 1982 and January 1983 caused extensive damage to the beaches and shoreline developments along the California coast.

Water Levels and Sea Level Fluctuations

Gradual variations in water level occur through tides, storm surge, and long-term sea level fluctuations. Tidal action alone has little effect on long-term shoreline change, but when storm surge and high waves are superimposed, elevation and depression of the water level becomes an important agent in sediment transport.

As a result of the moon's elliptical orbit, there is a minimal distance between the moon and earth once during each revolution. When this coincides with spring, higher tides, called perigean spring tides, are generated. *Wood* [1976] shows a strong coincidence of catastrophic storms and perigean spring tides. One hundred of the most severe coastal storms between 1635 and 1976, including the Ash Wednesday storm of 1962, occurred at the time of perigean spring tides.

During the Wisconsin glacial period, approximately 15,000 B.P., sea level was about 120 m lower than it is today, and the shorelines of the Atlantic and Gulf coasts were 60–150 km seaward of their present position. Sea level reached within several meters of the present level about 5000 yr ago and has remained fairly stable since then. However, a slow rise over the past 2000 years has resulted in recession of shorelines and enlargement of coastal bays and sounds. Over the past 100 yr, the rise has been rapid, totaling slightly more than 30 cm [*Hicks and Crosby*, 1975].

Measurement of Shoreline Change

The national shoreline erosion maps are based on data acquired by a variety of methods ranging from precise engineering surveys to general appraisals of old photographs. The advantages and disadvantages of these methods are listed below [*Dolan et al.*, 1978]:

Repeated Ground Surveys

Cost: Data acquisition is expensive because of the large number of man hours required. Accuracy: Resolution on the order of 0.01 m ground distance. Advantages: (1) Measurements are direct. (2) Individual measurements may be updated at relatively moderate cost. (3) Methodology is commonly understood by the public. (4) Measurement is commensurate with local property records. Disadvantages: (1) Historical timeline of data usually not available. (2) Accuracy of measurement greatly exceeds the resolution of shoreline definition. (3) Along-the-coast density is poor. (4) Systematic updating of extensive coastal reaches is expensive and time consuming.

Historic maps and charts

Cost: Existing maps and charts are generally inexpensive, but costs associated with generating new maps are high. Accuracy: Estimates of map accuracy are often unavailable, but can be estimated in tens of meters. Advantages: Maps and charts from the mid-1800's are available for much of the United States, thus providing an unusually long time frame for determination of shoreline changes. Disadvantages: (1) Irregular availability. (2) Unstable map bases. (3) Low accuracy and resolution. (4) No correction for sea state or tide level.

Aerial Photography

Cost: Given the along-the-coast density of available data, the cost is rated as low. Accuracy: Resolution of data varies with scale of photography and methods employed. Errors in the range of 2.5 m ground distance are typical [*Dolan et al.*, 1980]. Advantages: (1) Along-the-coast resolution is high. (2) Historical data for the last 40 years are usually available. (3) Data are time-specific. (4) Shoreline definition is within the resolution error of systems being analyzed. (5) Repeated coverage is inexpensive if extensive coastal areas are included. (6) Frequent coverage in time is

Data Collection and Analysis

The national shoreline change data bank was created from the best and most comprehensive of existing information sets contributed by coastal scientists nationwide. Initially, the approach was to obtain maximum coverage by using the most readily available data sets. Preference was given to studies with a wide range, both temporal and spatial, and which were already available in graphic form. Once the broad reaches were covered, higher resolution, site-specific information was introduced. Appropriate district and division offices of the U.S. Army Corps of Engineers were contacted for information. Because of their involvement with the National Shoreline Study, the Corps was able to provide up-to-date lists of coastal scientists and other contacts who could provide data. Requests for data were also made to state offices with responsibility for coastal affairs, sea grant offices, and university departments.

Most contacts provided reports, data sets, and/or further contacts. It was quickly established that the mid-Atlantic, southeast, Gulf, and Great Lakes areas are data rich. In contrast, the Pacific, Alaskan, and northeast coasts have not been surveyed as extensively or quantitatively. These areas lack information because shoreline change is episodic and/or catastrophic so a continuous day-to-day threat is not perceived by the coastal communities, or the population densities are so low that continuous shoreline monitoring is not a high priority.

As the data were collected, they were transferred onto 1:2,000,000 scale Mylar transparencies. In many instances, two or more information sets were available for a given reach. In such cases, time span and currency of information were considered. More recent studies were chosen over older ones because they are generally made with knowledge of preceding work and reflect the earliest information. Where a choice of length of historical record appeared, long-term rates were favored over short term for two reasons: More of the data sets present average rates based on the study of charts drafted in the late 19th century onto which successive series of maps and aerial imagery were superimposed, so, using the longest period of record made the majority of studies similar in terms of the initial baseline, and the effects of single catastrophic events were filtered.

In areas where detailed information was not available for periods of over 100 yr, the measurement base or type became a criterion for inclusion. Since the development of mapping-quality aerial photography in the 1930's, the quantification of shoreline changes over large reaches of the coast has become possible. The period of record is generally 40–50 yr, and the studies or data are all current, so the effects of recent engineering structures are usually included.

The rate of shoreline change, length, and final year of study and measurement base are indicated on our 1:2,000,000 scale maps for each reach. At this scale, 2 km ground distance is 1 mm map distance. To record the maximum amount of information, all data were processed to conform with a minimum mapping unit of 5 mm. Where barrier islands are present, islands shorter than the minimum mapping unit are kept as a single unit. We attempted to group similar recession rates together but not to average rates for islands with significantly higher or lower rates on adjacent islands.

After all the data sets were recorded on the Mylar maps, the information was processed to create a set of maps, also at a scale of 1:2,000,000, on which rate classes are depicted in an easy to read manner (Figure 1). Our objective was to have broad enough classes to include significant variation about the low resolution means yet narrow enough to do justice to those high resolution studies with low variances. The errors involved in obtaining average rates of change from limited numbers of profiles is somewhat diminished by the use of rate classes. The broad classes will bracket the true rate for a given reach in an acceptable graphic form. For more detailed information, we will refer the users to the original data sources.

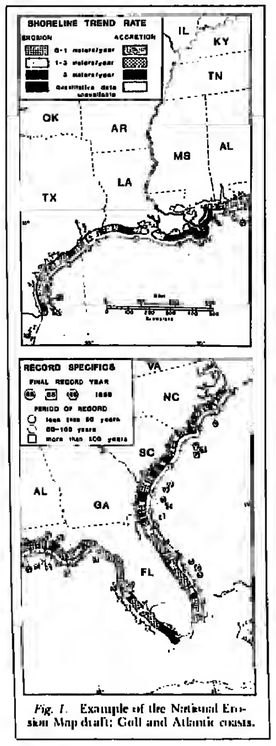

Fig. 1. Example of the National Erosion Map draft: Gulf and Atlantic coasts.

Fig. 2. Site-specific CEIS query.

Coastal Erosion Information System

All information gathered for the map series is contained in an easy-access computerized information system [*May et al.*, 1982]. CEIS is designed to provide the user with original rate-of-change data, primary sources, statistical summaries, and notes regarding special interest features for any given reach of coast. The information is stored in grid cells, which are 3 min latitude or longitude on a side. Each cell is filed and identified by the latitude and longitude of its northwest corner.

The system is designed in a tutorial mode for easy user access. Once logged into the system, the user must know prior to entering the system is the latitude and longitude of the area of interest. Rate-of-change information is printed out for each 3 min grid cell. Statistical summaries and data sources are listed for the reach (Figure 2).

Migration of the U.S. Shorelines: Summary

We used CEIS to generate statistical summaries of rate-of-change data for each coastal state and for reaches with almilor geology and shoreline geomorphology (Tables 1 and 2).

In Table 1, the mean rate of change for each coastal state, within-state standard deviations of these rates, and the extreme range of rates are listed. Along the Atlantic coast, the average erosion rate is about 0.8 m/yr (recession); with the Virginia barrier islands, Maryland, and New Jersey having the most pronounced erosion rates, up to 4.1 m/yr. The rapid erosion of Virginia's shoreline is largely confined to the Virginia barrier is-

Delaware bays. The only information that the

Article *(cont. from p. 521)*

TABLE 1a. Rate of Change Statistics for States and Regions: Oceanic Coastlines

Region	$\bar{x}$, m/yr*	σ	Total Range*		N†
Atlantic Coast	−0.8	3.2	25.5	−24.6	510
Maine	−0.4	0.6	1.9	−0.5	16
New Hampshire	−0.5	—	−0.5	−0.5	4
Massachusetts	−0.9	1.9	4.5	−4.5	48
Rhode Island	−0.5	0.1	−0.3	−0.7	17
New York	0.1	3.2	18.8	−22	42
New Jersey	−1.0	5.4	25.5	−15.0	39
Delaware	0.1	2.4	5.0	−2.3	7
Maryland	−1.5	3.0	1.3	−8.8	9
Virginia	−4.2	5.5	0.9	−24.6	34
North Carolina	−0.6	2.1	9.4	−6.0	101
South Carolina	−2.0	3.8	5.9	−17.7	57
Georgia	0.7	2.8	5.0	−4.0	31
Florida	−0.1	1.2	5.0	−2.9	105
Gulf of Mexico	−1.8	2.7	8.8	−15.3	358
Florida	−0.4	1.6	8.8	−4.5	118
Alabama	−1.1	0.6	−0.8	−3.1	16
Mississippi	−0.6	2.0	0.6	−6.4	12
Louisiana	−4.2	3.3	3.4	−15.3	106
Texas	−1.2	1.4	0.8	−5.0	106
Pacific Coast	−0.0	1.5	10.0	−5.0	305
California	−0.1	1.3	10.0	−4.2	164
Oregon	−0.1	1.4	5.0	−5.0	86
Washington	0.5	2.2	5.0	−3.9	46
Alaska	−2.4	2.0	2.9	−6.0	69

*The negative values indicate erosion; the positive values indicate accretion.
†Total number of 3-min grid cells over which statistics are calculated.

TABLE 1b. Rate of Change Statistics for States and Regions: Bays and Lakes

Region	$\bar{x}$, m/yr*	σ	Total Range*		N†
Delaware Bay					
New Jersey	−1.9	1.3	0.3	−3.0	13
Delaware	−1.3	2.1	5.0	−3.0	12
Chesapeake Bay	−0.7	0.7	1.5	−4.2	136
Western shore	−0.7	0.5	1.5	−1.9	67
Maryland	−0.7	0.3	−0.1	−1.3	35
Virginia	−0.8	0.7	1.5	−1.9	32
Eastern shore	−0.7	0.8	0.1	−4.2	69
Maryland	−0.8	0.9	−0.3	−4.2	47
Virginia	−0.5	0.4	0.1	−1.2	22
Great Lakes	−0.7	0.5	0.6	−2.7	327
Lake Erie	−0.7	0.6	−0.2	−2.4	98
Ohio	−0.6	0.6	−0.2	−2.2	68
Pennsylvania	−0.3	0.1	−0.2	−0.4	14
New York	−1.4	0.6	−0.5	−2.4	20
Lake Ontario	−0.5	0.2	−0.2	−1.2	58
Lake Huron	−0.4	0.3	−0.3	−1.3	28
Lake Michigan	−0.6	0.8	0.6	−9.9	184
Western shore	−0.6	0.4	0.6	−1.5	62
Eastern shore	−0.7	0.9	0.8	−9.9	122
Wisconsin	−0.7	0.3	−0.3	−1.5	46
Illinois	−0.2	0.4	0.6	−0.9	16
Indiana	−0.4	0.5	−0.3	−0.9	15
Michigan	−0.7	0.9	−0.3	−9.9	110
Lake Superior	−1.3	0.7	−0.3	−2.7	35
Minnesota	−0.8	0.4	−0.3	−1.5	16
Wisconsin	−1.8	0.6	−0.9	−2.7	19

*Negative values indicate erosion; the positive values indicate accretion.
†Total number of 3-min grid cells over which the statistics are calculated.

TABLE 2. Rate of Change Statistics for Coastal Landform Types

Region	$\bar{x}$, m/yr*	σ	Total Range*		N†
Mud flats					
Fla.	−0.3	0.9	1.5	−1.5	9
La.-Texas	−2.1	2.2	3.4	−8.1	84
All Gulf	−1.9	2.2	3.4	−8.1	93
Rock shorelinea					
Atlantic	1.0	1.3	1.9	−4.5	36
Pacific	−0.5	—	−0.5	−0.5	7
Pocket beachea					
Adantic	−0.5	—	−0.5	−0.5	9
Paeific	−0.2	1.1	5.0	−1.1	144
Sand beaches					
Maine-Mass.	−0.7	0.5	−0.5	−2.5	17
Mass.-N.J.	−1.3	1.3	2.0	−4.5	22
Atlantic	−1.0	1.0	2.0	−4.5	39
Oulf	−0.4	1.6	8.8	−4.5	121
Pacific	−0.3	1.0	0.7	−4.2	19
Sand beaches with rock headland	0.3	1.9	10.0	−5.0	134
Deltas	−2.5	3.5	8.8	−15.3	155
Barrier Islands					
La.-Texas	−0.8	1.2	0.8	−3.5	76
Fla.-La.	−0.5	1.7	8.8	−4.5	82
Gulf	−0.6	1.5	8.8	−4.3	158
Maine-N.Y.	0.3	2.6	4.5	−1.5	12
N.Y.-N.C.	−1.5	4.5	25.5	−24.6	153
N.C.-Fla.	−0.4	2.6	9.4	−17.7	256
Atlantic	−0.8	3.4	25.5	−24.6	421

*Negative values indicate erosion; the positive values indicate accretion.
†Total number of 3-min grid cells over which the statistics are calculated.

average. Erosion rates along Chesapenke Bay's shoreline are of the same order as the Atlantic coast average. Overall, the Atlantic coast can be characterized as a receding system, with 408 of the 510 grid cells (79%) showing some measure of erosion.

The Gulf coast states have the distinction of having the most rapid average erosion rates (1.8 m/yr) on a national scale, almost 5 times the average for our total 1089 sites. Within the Gulf coast region, the deltaic coast of Louisiana is by far the most dynamic (4.2 m/yr erosion). Like the Atlantic coast, the Gulf region can be described as eroding. However, the percentage of receding areas is somewhat less (83%). This is due, in part, to the large area covered by the active Mississippi delta system and, in part, to extensive regions in southern Florida that are essentially unmapped.

In general, the Great Lakes shorelines are receding at rates (0.8 m/yr) commensurate with the Atlantic coast. The highest erosion rates are found along the shorelines of Lake Superior (1.3 m/yr) and Lake Erie (0.7 m/yr). Both these lakes have long east-west dimensions and, thus, large fetches during the eastward passage of storms. The Pacific coast, including Alaska, has the lowest erosion rates (0.005 m/yr), as indicated by the available sources, as well as the lowest overall percentage of eroding areas (less than 50%).

While erosion rates for the bays and lakes are of the same order as for ocean coasts, the along-the-coast variability is much lower. For example, Chesapeake Bay (0.7 m/yr recession) and the Atlantic coast (0.8 m/yr recession) have about the same mean rate of change, but the along-the-coast variability for the Adantic coast (±3.2 m/yr) is an order of magnitude higher than that of Chesapeake Bay (±0.7 m/yr).

When the national erosion rates are grouped on a basis of the shorezone geology, the resulting patterns are, for the most part, as one would expect (Table 2). We used the four rock-type categories listed on the coastal landforms map published in the *National Atlas [U.S. Geological Survey,* 1970] and subdivided each rock type into the geographic regions. Coasts with fine-grained sediments, deltas, and mudflats have the highest mean erosion rates (2.0 m/yr neression), while most sandy beaches and barrier islands are eroding at lower rates (0.8 m/yr). The rock shorelines of the Atlantic coast (Maine) and the glacial rebound areas are accreting at 1.0 m/yr.

Table 2 also provides a listing of the erosion rates for the 295 Gulf and Atlantic coast barrier islands. The Gulf coast barrier islands are receding at a mean rate of 1.6 m/yr, with some islands having erosion rates as high as 15.3 m/yr. The Atlantic coast mudflats have the highest mean erosion rates (2.0 m/yr recession), while most sandy beaches and barrier islands are eroding at lower rates (0.8 m/yr). The rate of Atlantic coast barrier island recession over the last 2000 yr varied as the rate of the sea level rise changed, the supply of sediment waned, and the inner shelf slope evolved. Some of the eroded material has been lost into large offshore sediment sinks, such as Diamond Shoals off Cape Hatteras. Much of it, however, has remained within the barrier island sediment budget and has contributed to spit growth, inlet filling, dune building, and storm overwash deposits.

Acknowledgments

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Forum

Methane and Seismicity: A Reply

In a recent Forum article in *Eos* ("Methane in Association With Seismic Activity," June 14, 1983, p. 410), R. S. Orcutand presents observations which he claims contradict the deep methane gas hypothesis. His principal case rests on observations of one M 5.7 earthquake near the volcanic area of Mammouth Lakes, California, which did not result in any increase in methane content of gases in four local seeps.

In our published discussions of the deep gas hypothesis [*Gold and Soter,* 1980, 1982], we proposed (1) that outgassing from mantle depths is an ongoing process both in volcanic and nonvolcanic regions; (2) that the gases CO_2 and CH4 are the principal carriers of the surface excess carbon; (3) that chemical equilibrium between CO_2 and CH_4 in the presence of hot or liquid ruck is strongly shifted towards CO_2, especially in the low pressure domain, and that therefore active volcmic or high heat flow regions would be less likely to exhibit CH_4; and (4) that faultlines, particularly those which are seismically active, are locations where outgassing in cool regions can be sampled. The evidence there is that flames from the ground are often seen in association with major earthquakes. (Just as in many mnd volcano eruptions, ignition of combustible gases can be attributed to electrostatic effects.) Methane is also observed in many of the major crustal rifts, together with helium having the high ^3He to ^4He ratio indicative of deep origin [*Lupton,* 1983].

Based on this type of evidence we concluded that methane was very likely the combustible component that escaped sometimes during earthquakes, although hydrogen is also a good possibility. Of course there are great regional variations in the type of gas found in deep wells and we would expect this to be reflected in regional variations in the gases that escape during earthquakes. The observation of one moderate earthquake with no associated increase in the methane outgassing in four seeps can hardly be regarded as a contradiction to the deep gas hypothesis. It also does not add to or subtract from the evidence of flames in the Owens Valley earthquake of 1872. All that can be said is that no combustible gases were observed in the Mammouth Lakes earthquake of 1978, just as no combustible gases have been observed in many other earthquakes. Combustible gases have, however, been observed in a large number of other cases, particularly during major earthquakes in which faulting extended to the surface.

The low levels of methane found in most volcanic emissions may be due either to its absence in the source gases entering the magma chamber, or to its oxidation there, which must certainly be expected. At great depths, methane tends to be pressure-stabilized despite the high temperatures. But most of the deep source methane which finds its way into the Equnil rock of a volcano will probably be oxidized to CO_2 as it comes into contact at reduced pressures with the abundant oxygen available in the hot magma. Nevertheless, methane has been detected in numerous volcanic emissions, sometimes even at combustible concentrations.

Orcutand claims that such mineral-catalyzed oxidation of CH_4 to CO_2 is not supported by experimental evidence and he cites *Sackett and Chung* [1979] to that effect. However, those authors demonstrate merely the absence of isotopic and chemical equilibrium between CH_4 and CO_2 heated to 500°C for several days. *Giggenbach* [1982] has since shown theoretically that equilibration under such conditions is expected to be negligible in times less than a year, but should go to completion in a few hundered years. Certainly at the high temperatures (and low pressures) of a volcanic vent the equilibration will be very rapid.

The statement that organic debris can account for some of the methane in volcanoes does not contradict our hypothesis that some volcanic methane has a deeper origin, as Orcutand seems to suggest.

Lastly, Orcutand claims that "observations of isotopically heavy methane. . .in association with plumes of ^3He emanating geothermal regions. . .does not prove a mantle origin for the methane because the gas may have been 'stripped' out of the crust with upward movement of ^3He." It must of course be the other way around. ^3He is never present at a level of more than one part in 10^7 of any natural gas. How this minute trace constituent would sweep up more than ten million times its own volume as it moves through the crust would surely be a major puzzle. It is more reasonable to suggest that the CO_2 and isotopically heavy CH_4 are carriers for the ^3He with which they are so often found associated.

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News

Solar System Around Vega?

The Infrared Astronomy Satellite (IRAS), launched in January, has discovered a shell or ring of particles around Vega, the brightest star in the constellation "The Lyre" and one of the brightest stars in the sky. The discovery provides the first direct evidence that solid objects of substantial size exist around a star other than the sun; it also offers the first scientific opportunity to study what may be an early solar system accreting from stellar debris, much like our solar system is believed to have formed.

IRAS measured the material to be at a temperature of 90° Kelvin, about the temperature of particles in Saturn's innermost rings. Although the sensitive telescope on IRAS cannot discern the individual particles around Vega, scientists speculated that the particles could range from the size of a pearl to the size of an asteroid or planet. In addition, the composition of the particles is open to debate. The material around Vega probably has not reached the same stage of evolution as our solar system because Vega is less than one fourth as old as our sun.

Vega, about 26 light years from earth, is a standard against which other stars' brightness and spectra are measured by astronomers. In fact, it was while IRAS scientists H. H. Aumann of the Jet Propulsion Laboratory and Fred Gillett of Kitt Peak National Observatory were using Vega to calibrate the IRAS telescope that they discovered that the star appeared much brighter and larger in infrared light than expected based on IRAS observations of similar stars. The scientists determined that the radiation is coming from an extended region around the star stretching out roughly 80 astronomical units from Vega. Aumann and Gillen were working with telescope data at the IRAS tracking and data acquisition center at the Rutherford Appleton Laboratory in Chilton, England, when they made the discovery.

The IRAS infrared telescope measures heat radiation emitted by celestial objects. The telescope is scheduled to operate through January; its mission is to survey and map all infrared objects in the sky. Followup studies from infrared, optical, and other telescopes will gather information on the distribution and composition of the material. IRAS is a joint project of the United States, the United Kingdom, and the Netherlands. The Jet Propulsion Laboratory is the U.S. management center for IRAS.

New Editors Appointed

New editors have been appointed for the Atmospheres and the Oceans sections of the *Journal of Geophysical Research* (JGR), for the policy sciences portion of *Water Resources Research* (WRR), and for *Reviews of Geophysics and Space Physics* (RGSP).

William L. Chameides, associate professor at the School of Geophysical Sciences at the Georgia Institute of Technology has been appointed editor of JGR–Atmospheres beginning January 1, 1984. He succeeds Ralph Cicerone.

Chameides, who has been an associate editor JGR and *Geophysical Research Letters* (GRL), received his B.A. in physics from the State University of New York at Binghamton in 1970 and his Ph.D. in geology and geophysics from Yale University in 1974. Manuscripts submitted to JGR–Atmospheres after October 1, 1983, should be sent to William L. Chameides, School of Geophysical Sciences, Georgia Institute of Technology, Atlanta, GA 30332 (telephone: 404-894-3885).

James J. O'Brien, professor of meteorology and oceanography at Florida State University (FSU), has been appointed editor of JGR–Oceans beginning January 1, 1984. He succeeds A. D. Kirwan, Jr.

O'Brien, director of graduate studies at FSU's department of meteorology, received his B.A. in chemistry from Rutgers University in 1957 and his Ph.D. in meteorology from Texas A&M University in 1966. He has served as an associate editor of GRL and is the immediate past president of the AGU Oceanography Section. Manuscripts submitted to JGR–Oceans after October 1, 1983, should be sent to James J. O'Brien, Editor, JGR-Oceans, P.O. Box 2173, Tallahassee, FL 32316 (telephone: 904-644-4581).

Ronald G. Cummings, professor of economics at the University of New Mexico, has been appointed editor of the policy sciences section of WRR beginning January 1, 1984. He succeeds Jared L. Cohon.

Cummings, director of the university's program in natural resources economics, received his B.S. in economics from the University of Missouri in 1963 and his Ph.D. in economics from the University of Missouri in 1968. He was chairman of the department of resource economics at the University of Rhode Island from 1972 to 1975 and is president of the Association of Environmental and Resource Economists. Manuscripts submitted to WRR after October 1, 1983, in the policy sciences of water resources including economics, systems analysis, sociology, and law, should be submitted to Ronald G. Cummings, Department of Economics, University of New Mexico, Albuquerque, NM 87131 (telephone: 505-277-3056).

James R. Heirtzler, senior scientist at the department of geology and geophysics at the Woods Hole Oceanographic Institution (WHOI), has been appointed editor of RGSP beginning July 1, 1984, succeeding Andrew F. Nagy. Heirtzler will be editor-designate from January 1 to June 30, 1984. Papers submitted to RGSP through the first quarter of 1984 should continue to be sent to Nagy.

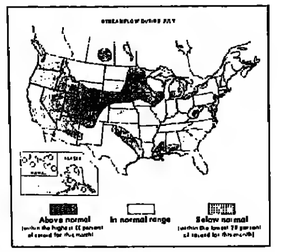
Heirtzler, who has published extensively in the field of geomagnetism, is the president of AGU's Geomagnetism and Paleomagnetism Section and was chairman of WHOI's department of geology and geophysics from 1969 to 1976. He received his B.S. in physics from Louisiana State University in 1947 and his Ph.D. in physics from New York University in 1953. Heirtzler was director of the Hudson Laboratories of Columbia University from 1967 to 1969 and director of scientific research of the Joint Oceanographic Institutions, Inc., in 1979–1980.

July Streamflow

The lingering effects of a record-deep mountain snowpack continued to keep streamflows at near record high levels in much of the western United States during July. Elsewhere in the nation, a lack of rainfall and prolonged high temperatures contributed to declining streamflows, and parts of the northeast and southeast reported near record-low streamflows, according to a monthend check on water conditions by the U.S. Geological Survey (USGS). (See map, courtesy of USGS.)

USGS hydrologists said that record-high streamflows were set in California, Colorado, Oregon, Utah, Washington, Wyoming, and Iowa based on reports from 172 key index stations across the country. Well above average flows during July, within the highest 25% of record, were reported at 57 of the index gaging stations. Of the remaining stations, 98 reported near-average flows and 17 reported well below average flows. Along the east coast, 12 of the 72 key index stations from Maine to Florida reported well below average flows for the month. In the extreme southwest, two stations reported their lowest July flows for the period of record.

The combined flow of the three largest rivers in the coterminous United States—Mississippi, St. Lawrence, and Columbia—which drain more than half of the 48 states, reflected the generally wet conditions. The average flow for the three rivers during July was 8946 billion liters per day (bld) (736 billion gallons per day), 20% above average, but down seasonally by 48% from June's flow. The flow of these large rivers serves as a convenient check for hydrologists in appraising the nation's surface water conditions.



Working in cooperation with federal, state, and local officials, the USGS routinely monitors the quantity and quality of the nation's surface and groundwater resources at more than 45,000 stations across the country. Flows of the "Big Five" rivers in July were as follows: Mississippi River at Vicksburg, Miss., 1614 bld, 29% above average for July, but 56% below the near-record flow in June; Columbia River at The Dalles, Ore., 915 bld, 10% above average, but 34% less than last month's flow; St. Lawrence River near Massena, N. Y., 827 bld, 3% above average, but down 5% from June's flow; Missouri River at Hermann, Mo., 323 bld, 45% above average for July, but down 28% from June; and the Ohio River at Louisville, Ky., 150 bld, 4% above average, but 39% below the June flow.

News *(cont. on p. 524)*

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S. Kimball May holds a B.A. from the College of William and Mary, a M.S. in geophysics from Ball State University, and a Ph.D. in coastal processes from the University of Virginia. She is currently a research associate with the Virginia Institute of Marine Science and the University of Virginia. Her research has been concentrated on the definition, classification, and prediction of analog coastal environments. For the past year, S. Kimball May has worked with the statistical analysis of regional scale coastal processes, specifically the interactions among cyclone frequency, wave energy, and nearshore profile response.

Robert Dolan received his B.S. from Southern Oregon College, M.S. from Oregon State University, and his Ph.D. from Louisiana State University. He has been at the University of Virginia since 1965 and is past chairman of the Department of Environmental Sciences. Robert Dolan has been responsible for the management of numerous research projects in the coastal regions, leading to more than 100 publications on coastal processes, shoreline dynamics, guidelines for classification of coastal environments, barrier island dynamics, and shoreline erosion. His research has been sponsored by the Office of Naval Research Coastal Sciences Program, the National Space and Aeronautics Administration, the National Park Service, and the U.S. Geological Survey. He has served in an advisory capacity for the Geological Survey and Park Service and has a number of research efforts underway related to coastal dynamics. Presently, he is serving as a liaison scientist with the Office of Naval Research in London.

Bruce P. Hayden is associate professor of Environmental Sciences at the University of Virginia. He received his undergraduate education at Pennsylvania State University in zoology and botany and his Ph.D. from the University of Chicago in biometeorology. Bruce Hayden spent 2 years as a post-doctoral research associate within the climatology program of Reid Bryson at the University of Wisconsin. Since joining the faculty at the University of Virginia, he has worked closely with Robert Dolan on designing experiments and on the analysis of coastal data sets to describe regional-scale shore-zone processes. His publications include contributions in coastal meteorology, ecology, geology, and management.

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Cover. Enhanced sun illumination image of the geoid over the South Pacific derived from SEASAT and GEOS-3 altimeter data. Illuminations are from the northwest (top/center) and southeast (bottom). Shorter wavelength geoid undulations reflect bathymetric features such as large seamounts (e.g., San Felix Island at 26.5°S, 280°E) and fracture zones (e.g., the Heezen, Tharp, and Udintsev Fracture Zones, bottom center). The largest linear feature is the Eltanin Fracture Zone, which is associated with a major age offset in the seafloor. The northwest extension of this fracture zone is the Louisville Ridge. The Kermadec Trench appears in the northwest corner. In addition to these known features, this map reveals a number of fracture zones and seamounts that have not been detected previously or were poorly charted because of sparse bathymetric coverage. (Photo courtesy of David T. Sandwell, National Geodetic Survey, Rockville, Md.)

NSF Education Grants

The National Science Foundation (NSF) is soliciting proposals for the development of educational materials and training workshops for science and mathematics programs in elementary and secondary schools. Proposals may be submitted at any time and must specifically deal with projects in mathematics, engineering, the natural sciences (including atmospheric, earth, and ocean sciences, physics, astronomy, chemistry, and biology), and computer science.

Projects for materials development may deal with programs for the continuing education of teachers; the development of teaching aids to improve classroom instruction; analyses of current elementary and secondary level programs; the improvement of communication among professionals in the field; or applied research directed at understanding and improving instruction and learning.

Proposals for workshops may offer to establish guidelines for identifying effective teachers and improving the prestige accorded them; to conduct workshops which offer specialized training; to create workshop materials; to improve the impact of workshops; or to conduct surveys during workshops in order to identify current trends and problems.

The current budget for the materials development program is $12 million; the budget for the workshop program is $2 million.

NSF will evaluate submissions on the basis of the quality of personnel participating in the project, on the inclusion of appropriate contributions from various private and public sectors, on the effectiveness of the internal evaluations built into the project, on the design quality of any proposed products, and on the potential impact the project may have for improving current educational programs.

All proposals should reflect an awareness of the diverse needs of different teacher and student populations. The foundation strongly encourages women and minorities to enter the national competition for these grants.

For more information contact Materials Development (or Honors Workshops) for Precollege Science and Mathematics, Office of Scientific and Engineering Personnel and Education, National Science Foundation, Washington, DC 20550 (telephone: 202-357-7539).

New NAS Journal

In April 1984 the National Academy of Sciences (NAS) will begin publishing a new quarterly focusing on science policy. Written primarily for legislators, diplomats, corporate managers, security analysts, and other public policy analysts, the new journal will deal with such diverse topics as arms control, economic competition, social change, and health care.

Original articles are expected to create a 120-page periodical that will discuss policy issues on a sophisticated but nonspecialist level, in a manner similar to that which *Foreign Affairs* uses to discuss U.S. foreign policy topics, according to NAS.

The National Academy of Engineering and the Institute of Medicine will be copublishers of the journal.

Geophysicists

The following AGU members were elected Fellows of the American Association for the Advancement of Science (AAAS) on May 30: ***Bruce Blanchard, Thomas E. Eastler, Robert L. Fleischer, Hans-Walter Georgii, Neil S. Grigg, Chester W. Newton, Louis G. Pehlser, Jr., Willard J. Pierson, Jr., Malcolm Ross, Harlan J. Smith, Robert L. Smith, Victor D. Vaeginer, Joseph Veverka, Fred N. White, and Charles A. Zraket.***

Larry D. Brown has been elected associate professor of geological sciences at Cornell University. Brown is a co-principal investigator of COCORP (Consortium for Continental Reflection Profiling).

Vernon E. Derr, a physicist and for the past 3 years deputy director of the National Oceanic and Atmospheric Administration's (NOAA) Environmental Research Laboratories (ERL) in Boulder, Colo., has been appointed ERL director, effective last month. He succeeds ***George H. Ludwig***, who resigned from the post in June (*Eos*, July 19, 1983, p. 459). Derr is a specialist in spectroscopy and laser development and application. A pioneer in the use of lasers in studying the properties of clouds and aerosols, his current research focuses on the optical properties of clouds and their effects on climate.

A. Ivan Johnson, a consulting engineer, received the 1983 Frank W. Reinhart Award from the American Society for Testing and Materials (ASTM). He was cited for his leadership on nomenclature for soil and rock mechanics and his work on the development and maintenance of definitions of terms relating to soil and rock mechanics. The Frank W. Reinhart Award is presented by the Society Committee on Terminology to a technical committee, subcommittee, or ASTM member who has made an outstanding and unusual contribution to ASTM in terminology standardization.

Clifford Murino was elected president of the University Corporation for Atmospheric Research (UCAR) by the UCAR Board of Trustees. Currently president of the Desert Research Institute of the University of Nevada system, Murino will begin his duties as UCAR president on September 1. He succeeds ***Robert M. White***, the new president of the National Academy of Engineering. Before assuming his University of Nevada post in 1980, Murino had been director of the National Center for Atmospheric Research's (NCAR) atmospheric technology division for 5 years. Before moving to NCAR, he spent 20 years at Saint Louis University in various capacities.

In Memoriam

Eric S. W. Simpson, a leading figure in marine geological and oceanographic research, died in June. A professor at the University of Cape Town in South Africa, he was a former president of the Scientific Committee on Oceanic Research (SCOR) and was chairman of the Commission on Marine Geology of the International Union of Geological Sciences (IUGS). AGU Life Member and a member of the Tectonophysics section, he joined AGU in 1971.

Nominations for Medals and Awards

William Bowie Medal. Awarded for outstanding contributions to fundamental geophysics and for unselfish cooperation in research.

Maurice Ewing Medal. Honors an individual who has led the way in understanding the physical, geophysical, and geological processes in the ocean; who is a leader in ocean engineering, technology, and instrumentation; or who has given distinguished service to the marine sciences.

Robert E. Horton Medal. Given for outstanding contributions to the geophysical aspects of Hydrology.

James B. Macelwane Awards. Up to three awards are given each year for significant contributions to the geophysical sciences by a young scientist of outstanding ability. Recipients must be less than 36 years old.

Letters of nomination outlining significant contributions and curriculum vitae should be sent directly to the appropriate committee chairmen: *Bowie Medal* - Eugene M. Shoemaker, U.S. Geological Survey, 2255 Gemini Drive, Flagstaff, AZ 86001; *Ewing Medal* - Robert O. Reid, Department of Oceanography, Texas A&M University, College Station, TX 77843; *Horton Medal* - R. Allan Freeze, Department of Geological Sciences, University of British Columbia, Vancouver, B.C., Canada V6T 1W5; *Macelwane Award* - J. Freeman Gilbert, IGPP A-025, University of California/San Diego, La Jolla, CA 92093.

Deadline for Nominations is November 1, 1983.

A. Ivan Johnson

Books

The Surface of Mars

M. H. Carr, Yale University Press, New Haven, Conn., xiv + 232, 1981, $45.

Reviewed by Peter H. Schultz

Surface features revealed by the Viking Orbiter were 10 times smaller than those recorded by Mariner 9, 30 times smaller than those features seen from Mariners 6 and 7, 300 times smaller than those features in Mariner 4 images, and 15,000 times smaller than our best pre-1964 earth-based views. The book about Mars had to be rewritten following each increase in resolution. Mutch et al. (*The Geology of Mars*, Princeton University Press, Princeton, N.J., 1976) and W. K. Hartmann and O. Raper (*The New Mars*, NASA Spec. Publ. 337, 1974) provided us rewrites following Mariner 9. Carr provides us a comprehensive rewrite following the historic Viking missions.

With the diversity of perspectives possible, Carr focuses on surface features. *The Surface of Mars* may appear to be a geomorphic text, but is much more than simply descriptions of features. Carr concentrates on the broader implications of features such as their clues for past fluvial activity and evidence for a different paleo-climate. Such implications are not dropped but are used to link different disciplines such as the evolutions of the atmosphere and the interior. Such an approach might seem narrow to some and frustratingly broad to others, but it is a view that permits Carr to pose the most basic questions and in consider first-order answers. He presents a somewhat personal view by no means singular or with tunnel vision. As leader of the Viking Orbiter Imaging Team, he witnessed conflicting and evolving interpretations while the Viking Orbiter relayed new data. Much of this evolution of thought is extensively referenced to current research (up to late 1979), including his own opinion of controversies and judgments. Although some may argue with his opinions, the approach provides a coherence difficult to achieve in group-authored or chapter-authored books. It also serves to focus points of contention, to challenge those with conflicting ideas, and to reveal broad areas remaining to be studied.

Perhaps the greatest strength in this book is the overall clarity of style and methodical approach. He treats Mars as its own planet, much as a terrestrial geologist treats the earth. We are not overwhelmed by terrestrial or lunar analogies, just as a terrestrial geology text is not overwhelmed by lunar or martian analogies. He introduces Mars in a concise overview that describes its surface and processes, thereby familiarizing the newcomer with its place among the inner solar system planets. As greater detail is considered in subsequent chapters, he interjects his own observations and interpretations, which occasionally are lost in the syntheses of other research. But such personal contributions provide a subtle and important thread that holds the book together. This approach, which brings solidity to the book, also brings an occasional impression that the surface of Mars is well understood, an overstatement underscored by the diversity of features and equal diversity of interpretations.

Because Carr has produced a personal view, I have several personal quibbles. The historical perspective provided in the first chapter is adequate but lacks important references and a good view of the pre-1967 observations of Mars. For example, no mention is made of pre-mission conferences such as the results from the 1965 CalTech-JPL Lunar and Planetary Conference or the systematic astronomical studies of Mars such as C. F. Capen's report about the 1964–1965 Mars apparition. Only token reference is made to G. de Vaurouleur's classic text about Mars. Such references are important, not only for a full picture of pre-Mariner efforts but also to instill a certain caution in accepting current "truths" with our present yet still incomplete data sets or parochial viewpoints.

The book is profusely illustrated with Viking images and salient graphs or diagrams from journal articles. In contrast with Mutch et al.'s book, *The Geology of Mars*, however, very few of the nonphotographic illustrations are original. In several instances, sketches or explanatory diagrams could have substantially clarified conflicting interpretations or described processes. Carr provides, nevertheless, a generally coherent discussion of a wealth of facts and concepts. Only occasionally are there lapses in understanding or communication. For example, on page 15 Carr uses the absence of craters in the polar deposits as evidence for recent formation, whereas in fact it indicates active processes that can continuously reshape an old surface. On page 30 he defines "optical depth" for the reader but introduces it on page 27. He presents a somewhat confusing account of the formation of central peaks on page 43, not distinguishing between slope failure (slumping) and plastic flow of the impacted region. He also notes that pits are rare on the moon and Mercury, but such features are certainly common on the moon. On page 62 Carr furthers the idea, based on Mariner 9 images, that extensive mantling has produced the broad featureless regions north of 40°N. The higher resolution Viking images have shown clearly that these regions have a wealth of detail, and the quoted Mariner 9 view largely reflects the effect of haze and oblique viewing angles, a lesson actually learned from Mariners 6 and 7. Carr confuses the accepted usage of the terms impact crater "saturation" and "equilibrium" on page 57, and he switches from incremental crater distributions to cumulative distributions without explanation or warning. On page 70 he implicitly assumes that ridges indicate volcanic plains, but in other sections of the text he clarifies this assumption. In the section on the poles, Carr does not clarify the distinction between the polar cap and the polar layered terrains.

Such nitpicking also applies to editorial and layout errors. For example, upside-down or sideways photographs occur, but are rare. Several misspellings, truncated sentences, and editorial glitches also were found. Although dimensional scales were consistently given for the martian images, ironically they were generally absent from terrestrial photographs. Such criticisms are relatively minor and perhaps stand out only because of the otherwise excellent production.

I found *The Surface of Mars* a stimulating reference that should be on the shelf of anyone wishing a detailed look at the geologic evolution of another planet. But the last word on Mars has not been written. Large quantities of relevant material have been published since 1979 that either are not referenced here or are referenced very incompletely. This is not damning criticism. This is merely testimony that the study of Mars does not simply end at the end of the final mission report. Mike Carr's book provides us a comprehensive status report. It stimulates researchers active in the field both by its synthesis of diverse data and by reaction to his personal views. I am sure this is what he wanted.

Peter H. Schultz is with the Lunar and Planetary Institute, Houston, TX 77058.

The Earth's Climate: Past and Future

M. I. Budyko, *Int. Geophys. Ser.*, vol. 29, Academic, New York, x + 307, pp., 1982, $39.50.

Reviewed by A. Berger

This is not simply another specialized book on climate variations. It is a welcome comprehensive review of the scientific contributions of M. I. Budyko and his colleagues from the Soviet Union.

M. I. Budyko, from the Main Geophysical Observatory in Leningrad, is an original thinking climatologist well known in the field of climate modeling. His results have been published mainly in Russian, but several important papers and books were fortunately published or translated into English. Among them let us remember his *Atlas of the Heat Balance*, *Climate and Life*, and *Climatic Changes*.

Since the 1960's, M. I. Budyko has been very active in research on man's impact on the environment, drawing the conclusion that a drastic change toward warming will occur during the next few decades if modern trends for generating energy continue. As it is now widely believed that anthropogenic climatic change is indeed highly probable, the author thought it was timely to tie together results obtained during the past 10 years. The very last papers are not included, but this is compensated for by a good overview of Russian literature that is usually not available to western scientists.

After a general overview of the more important milestones in climate change research covering both facts and theories, the author discusses the evolution of atmosphere with a special emphasis given to the carbon cycle, stressing the importance of ocean-biosphere-atmosphere interactions. This could have been well described in a flow diagram, but the six-page summary gives a good idea of the main processes responsible for it. This chapter ends with the variations in the chemical composition of the atmosphere on geological time scales dealing especially with carbon dioxide and oxygen and their related effects on living bodies. The two main conclusions are that variations in atmospheric O_2 content definitely influenced the evolution of the animal world, whereas fluctuations in the CO_2 concentration were accompanied by variations in the mass of autotrophic plants and consequently by variations in the total mass of living matter on our planet.

Chapter 5, one of the two more original chapters (the other being chapter 6), focuses on a semi-empirical theory of climatic change. There is an excellent description of the newly improved maps of the heat balance components of the earth-atmosphere system that have been constructed and published in Russia by Budyko et al. in 1978. From the data given in Table 3.2, it can be seen that as the heat balance at the earth's surface improves, the values of absorbed short-wave radiations (48% of the solar constant), of radiation balance (31%), and of heat loss from evaporation (26%) appear to increase by 16–20% and approach the results obtained by Houghton in the 1950's except for the turbulent heat flux.

Taking into account the difficulty of applying more general climate theories to the study of its changes, M. I. Budyko attempts to use for this purpose semi-empirical models, which can be done only at the expense of restricted goals for the model, extensive parameterization of large-scale atmospheric processes, and the use of empirical relationships. Besides his annual model, M. I. Budyko describes extensively a sensitivity analysis of his seasonal model for variations in the solar constant and in CO_2 concentration. Under the title "Unambiguity of Climate," he discusses the stability of his simulated climate, pointing out the stable (e.g., white earth) and unstable glaciation regimes. For example, he concluded (1) that for the existing climate-forming factors, the present-day climate seems not to be unique (that is, a different climatic regime could exist as a new variant of partial glaciation of the earth with a larger area of ice coverage compared with that presently observed) and (2) that an ice-free regime would also take place if the heat income exceeds its present value. Taking into account that these results depend essentially on the albedo parameterization of the earth-atmosphere system with and without snow and ice cover, he derived that relative estimates of a solar constant decrease for various parameterizations of the latitudinal distribution of the albedo, which could cause a glaciation of the earth that lies in the 2–10% interval, whereas the most probable values are 3–5%.

However, the problem of earth's glaciation should be studied further to clear up incompletely solved questions, such as the stationary nature of the climate system and the effect of the changing atmospheric chemical composition (which explains the lack of traces of the earth's complete glaciation during Precambrian times). This is why M. I. Budyko's next chapter is devoted to natural climatic changes. The main interest of the author was deliberately CO_2, and very few pages are devoted to solar variability, astronomical variations of the elements of the earth's orbit, plate tectonics, and internal mechanisms such as cloudy polar ice and other albedo feedbacks.

Although not all geologists or climatologists agree that atmospheric carbon dioxide is the cause of the prevailing changes in temperature of the geological past and/or of the past century, the author stresses the remarkable fit he believes to exist between CO_2 and temperature curves. For most of the earth's early history, its atmosphere probably contained enough CO_2 to maintain fairly high air temperatures near the earth's surface: (1) in the early and middle Phanerozoic (600–300 million years ago), the CO_2 concentration was 6–10 times higher than at present (with a peak around the Devonian-Carboniferous), and the greenhouse effect made up for the lower value of the solar constant; (2) in the late Mesozoic (roughly 100 million years ago) it started to decrease gradually, leading to the Tertiary cooling trend and finally to the Quaternary ice age where astronomical factors started to influence the climate significantly only after the development of polar caps. The post-Pleistocene climatic variations are then presented with a long discussion (38 pages) on the thermal and precipitation regimes variations during the last century.

From the Russian works, Budyko concluded that a warming trend began at the end of the 19th century in the extraequatorial latitudes of the northern hemisphere, with a weakly pronounced maximum just before the turn of the century. This was followed by a slight temperature dip, which was soon replaced by a rapid temperature increase. The warming was especially marked during the cold season in the late 1910's and early 1920's. The positive temperature anomaly was greatest at the end of the 1930's; in the 1940's the warming trend was overcome by a cooling trend, which intensified in the 1960's. In the mid-1960's the mean air temperature in the northern hemisphere approached the level of the late 1910's.

Reasons for this present change in climate are then found in volcanic activity and in the atmospheric CO_2 concentration brought by man's economic activity. This is why chapter 5 is totally devoted to the changes in local and global climate induced by man. Budyko's demonstration of the carbon dioxide influence on climate is in general agreement with the scientific works published before the appearance of the Russian version of his book (1980). As a consequence, he did not include the most recent results that the increase in atmospheric CO_2 and its related change in temperature could be much less than was previously thought owing to a reduction in energy consumption and a diversification in energy production. This explains why he still predicts a temperature increase of 0.5°C by the year 2000 and 2.5°C by the year 2025 (and not around 2075 as is now believed) with a northward shift of the growing thermal zones by 1°–3° and by 10°–15° latitude, respectively, in comparison with present-day conditions. Very little is said, however, about early detection strategies of CO_2 climate signal and about the influence of other trace gases, the transient response of the climate, the role of the oceans, and the cloudiness radiation feedback, all factors that can alter the climate response to CO_2 forcing.

The last chapter deals with the distant future of climate and the biosphere. Here it must be pointed out that forward calculation of the astronomical variations points to a new ice age beginning within about 5000 years and not the 10,000–15,000 years mentioned in the book on the basis of an outdated calculation.

Against this background, Budyko's conclusions are that "By using the coal and oil reserves accumulated for hundreds of millions of years, man is restoring the chemical composition of the Late Tertiary period. . . . If this change in natural conditions occurred rather slowly, this process could be favorable for mankind. But the enormous rate of this process creates a number of problems whose solutions can not be so easy. . . . In connection with this, it is necessary to organize, as quickly as possible, broad interdisciplinary investigations of anthropogenic climatic changes and their impact on natural conditions, such studies having to be based on international cooperation."

Although Budyko's book may overemphasize the importance of carbon dioxide among all causes of climatic changes, climatic warming owing to carbon dioxide and other trace gasses nonetheless has to be taken seriously. Budyko has long been actively involved in concern over man's impact on the environment and on climate. His experience made this book a landmark in the development of climatology, and his view on biosphere and climate made it not only important but also of wide interest.

Andre Berger is head of the Institute of Astronomy and Geophysics Georges Lemaitre of the Catholic University of Louvain-la-Neuve, Belgium.

River Basin Planning: Theory and Practice

S. K. Saha and C. J. Barrow (Eds.), Wiley-Interscience, New York, xiii + 357 pp., 1981, $45.50.

Reviewed by Erhard F. Joeres

River Basin Planning is divided into three major parts and an appendix. Part 1, Theory of River Basin Planning, is led by an introductory chapter from the editors emphasizing the major human component in the complex sociotechnical attributes of river basin development. They present a forceful argument for a truly interdisciplinary approach to river basin planning. (The appendix subsequently suggests curriculum development for courses in river basin planning.)

Part 2, River Basin Planning: Environmental Issues, is supported by two chapters: one with a focus on soil conservation, the other on ecosystem protection. The soil conservation chapter by I. Douglas illustrates that slow, inadvertent changes may be more damaging in the long run than immediate, direct effects. It postulates that planning for people perforce will require planning for soil conservation as an ongoing activity. The case for environmental protection is somewhat weak because of the singular example chosen for illustration. The Gunung Mulu National Park in Sarawak, Malaysia, is in a fragile, humid, tropical forest region where any change per se is interpreted as being detrimental.

Part 3, by far the largest part of the book, is entitled River Basin Planning: Sociotechnomic Issues. Its chapters are divided into three general groups. In group one, a number of chapters deal with postdevelopment analyses of a variety of water development schemes. R. P. Lightfoot analyzes the resettlement experience associated with 11 major water development projects in Thailand; R. Windl looks at development achievements in the Awash Valley of Ethiopia; M. J. Shepherdson considers the demographic, environmental, and socioeconomic consequences of the vast irrigation scheme in the Indus River Basin of Pakistan; and E. Stern analyzes the role that inexpensive power from the Tennessee Valley Authority has played in the economic, social, and environmental development of that region.

Another group of chapters is methodological, intended either to illustrate possible development scenarios for the future or as pedagogical devices used to train planners in the complex decision processes necessary for water resources planning.

Included in the methodological group is the chapter by L. V. Tavares on a mathematical systems model for a large, multipurpose water resources project currently underway in the Alentejo Region of southern Portugal; the model selects the configuration and temporal and spatial investment sequence possible for the project under given economic assumptions. S. B. Watt presents a critical discussion of socioeconomic issues and their historical relationships for the development on the Senegal River in West Africa; and D. A. Rondinelli presents a role-playing model designed to highlight the necessary sequence of steps to be taken in irrigation planning.

A third group of chapters addresses the difficulty of translating the experience in one place into another, the economic benefits at one time into another, or the perspective of one agency into another. The chapter by A. Blackburn and D. Hughes-Evans discusses the value of comparing different planning approaches as highlighted by management of the Potomac River in the United States and the Thames in the United Kingdom; S. D. Briggs makes a case for ongoing research and development to allow for adjustment and reevaluation as uncertain socioeconomic parameters manifest themselves through time; and J. M. Sinnu focuses on the problem of vested interests and hidden agendas that surface when two governmental agencies set out to study the same water development scheme in Oyo State, Nigeria.

I found this to be a thoroughly useful book. A collection of papers such as this (17 in all) can always be criticized for varying from the overall scheme of the book. Although these are clearly some problems in this regard, I found the range of material, as well as the applications that have been assembled, quite remarkable. The book illustrates the importance of the many interlocking concerns—behavioral, technical, and environmental—which must be brought into focus if success in planning is to be achieved. Most important, the overriding importance of differing local determinants to the planning process is brought home through the broad range of examples. Although I might want to pick at some individual points, I would recommend the book as a valuable source for its comprehensive coverage. The most likely class application would be in a graduate water-resources planning and management seminar.

Erhard F. Joeres is with the Department of Civil and Environmental Engineering, University of Wisconsin–Madison, Madison, WI 53706.

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Dr. Raymond A. Castillo
ASRC—Earth Science 324
State University of New York at Albany
1400 Washington Avenue
Albany, New York 12222

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Tenure-Track Faculty Position-Geophysics/New Mexico State University. We are seeking a faculty member whose duties will include teaching both undergraduate and graduate level courses, conducting research and supervising graduate level thesis and dissertation research. We are particularly interested in a seismologist, but persons with experience in other geophysical techniques are invited to apply.

Minimum qualifications include an earned doctorate in geophysics or closely related areas and demonstrated research capability. Teaching experience and demonstrated ability to secure research funding are desirable. The position is available in January 1984 for 9-month academic year. Appointment will be at the rank of Assistant or Associate Professor. Salary and academic rank will be dependent on experience and qualifications.

Applications and names, addresses and telephone numbers of at least three references should be submitted to Dr. Chandler Swanberg, Department of Earth Sciences, P.O. Box 3AB, Las Cruces, NM 88003.

Applications received by October 15, 1983 will be given preference.

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The University of Missouri-Columbia/Faculty Positions. The University of Missouri-Columbia Department of Geology plans immediate expansion through the addition of three tenure-track faculty positions. Appointments are anticipated at the assistant professor level, although higher ranks may be possible, beginning in August of 1984. Candidates will be expected to have completed requirements for the Ph.D. degree by that time. Faculty members are required to provide quality instruction at both undergraduate and graduate level, and conduct research leading to scholarly publications. Successful candidates will be chosen from the following specialties:

Exploration Geophysics
Solid-Earth Geophysics
Hydrogeology
Analytical Structural Geology
Clastic Sedimentology

Applications should send resume, transcripts, and names and addresses of three references to:

Tom Freeman, Chairman
Department of Geology
University of Missouri
Columbia, MO 65211

Structural Geologist/University of Wyoming. The University of Wyoming, Department of Geology and Geophysics seeks applicants for a tenure track appointment in structural geology to be available beginning fall semester 1984 or earlier. Duties will include teaching at undergraduate and graduate courses in structural geology, supervising MS and PhD theses, and research in structural geology. Appointment at assistant professor level is preferred, but applicants requesting appointment at higher rank will be considered. Applicants must have a PhD degree and be versed in quantitative theory as well as field applications of modern structural geology and regional tectonics.

Applicants should provide a resume, names of three references and a letter of application including a statement of current research interests and courses which the applicant feels qualified to teach. Applications should be sent to: Dr. Robert S. Houston, Department Head, Department of Geology/Geophysics, PO Box 3006 University Station, Laramie, WY 82071.

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Geophysicist. New Mexico Institute of Mining and Technology invites applications for a tenure track position in exploration seismology at the assistant professor level to begin as soon as possible. The position will be a joint appointment between the College Division and the Research and Development Division. A PhD is required. Send letter of application, resume, brief description of teaching and research interest and names of three references to: Personnel, Brown Hall 17, New Mexico Institute of Mining and Technology, Socorro, NM 87801.

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Physicist/Computer Professionals. SSAI carries out hardware/software engineering support and physics related modeling studies with NASA/NOAA/NAVY scientists. For our on-going and future anticipated projects, we need Senior Professionals to carry out research, numerical analysis, modeling and simulation studies. These positions require atmospheric scientists with experience in GLOBAL CIRCULATION, STRATOSPHERIC DYNAMICS, PHOTOCHEMISTY, RADIATIVE TRANSFER AND TRANSPORT OR STRATOSPERHIC CONSTITUENTS BY MOTION. Professionals with experiences in SOLAR PHYSICS, DIFFERENTIALLY ROTATING STARS, STELLAR STRUCTURE ANO EVOLUTION MODELING ARE ALSO NEEDED. Applicants must have MS/PhO degrees and computational experience with large-scale machines and FORTRAN language. SSAI provides a congenial, academic work environment and awards yearly bonuses to all of its employees. Please send your resume with references and salary history to: SCIENCE SYSTEMS AND APPLICATIONS, INC. 1210 Greenbelt Rd., Seabrook, MD 20706.

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Iowa State University of Science and Technology, Department of Earth Sciences. Applications are invited for a tenure track faculty position in Meteorology. Rank is at the assistant or associate professor level, dependent upon qualifications. The successful applicant will be expected to develop a strong research and graduate student program and will teach undergraduate and graduate courses for meteorology majors.

The position is for a person with proven expertise within the general area of dynamic meteorology. Teaching will involve an undergraduate course in synoptic meteorology, in addition to courses related to the field of expertise. Completion of the Ph.D. prior to appointment is strongly preferred. In addition, research ability shown by other publications and/or postdoctoral experience will be an advantage.

Iowa State offers degrees in meteorology through the Ph.D. The program includes about 60 undergraduate majors; the graduate/research program is strong and emphasizes theoretical, dynamic studies. Close relationships are established with the facilities and personnel of major national laboratories. New campus facilities for meteorology are currently under construction.

The appointment is expected to begin no later than September, 1984; an appointment during the current academic year may be possible. Application deadline is November 1, 1983; later applications will be accepted if the position is not filled. For application information please write to:

Dr. Ben E. Mordie
Department of Earth Sciences
Iowa State University
253 Science I
Ames, Iowa 50011.

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Rensselaer Polytechnic Institute/A Tenure-Track Faculty Position and a Post-Doctoral Research Position. The Department of Geology of Rensselaer Polytechnic Institute is seeking applicants for two openings, a tenure-track faculty position and a post-doctoral research position.

The faculty position available in September 1984 requires a Ph.D. or equivalent degree. The area of specialization within the geosciences is open. Particularly important is the applicant's interest in research and teaching at both the undergraduate and graduate levels (M.S. and Ph.D.) with capability to do creative research in the quantitative sciences. Preference will be given to individuals with research experience beyond the Ph.D.; the level of the appointment is open.

The post-doctoral position is available beginning January 1984 to do research in the field of fission track analysis applied to studies of sedimentary basins. Applicants must be knowledgeable and experienced in fission track analysis.

Our present department is part of a modern, technologically-oriented university, and consists of seven members whose collective expertise encompasses structural geology, geophysics, geochemistry, petrology, glacial and surficial geology, and ecological modeling. The RPI environment provides ample opportunities for field and laboratory experimental research in geology, as well as for interdisciplinary studies in chemistry, physics, biology, mathematics, materials science, engineering and computer science.

A resume and the names of three persons who would be willing to provide letters of reference should be sent to: Donald S. Miller, Chairman, Department of Geology, Rensselaer Polytechnic Institute, Troy, NY 12181.

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Professor and Chairman, Ocean Engineering/University of Miami. Ocean Engineering, with a faculty of nine, is constituted both as a division of the Rosenstiel School of Marine and Atmospheric Science and as a department in the College of Engineering. In addition to performing routine administrative duties, the chairman is expected to take an active part in teaching and research; qualifications for this post include a record of accomplishment in these areas and an earned doctorate. The Rosenstiel School is embarking on a new five year plan that calls for vigorous growth in the Division. The new Chairman should be capable of fostering and guiding such growth.

Submit applications by January 1, 1984 to: Dr. Joseph M. Prospero, Chairman of the Search Committee, Division of Ocean Engineering, Rosenstiel School of Marine and Atmospheric Science, University of Miami, 4600 Rickenbacker Causeway, Miami, Florida 33149-1098.

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Groundwater Hydrologist/Jordan Gorrill Associates. The Geotechnical and earth science subsidiary of E.C. Jordan Co., Portland, Maine, has an opening for a senior groundwater hydrologist. Candidates should have an advanced degree in hydrogeology or geotechnical engineering and a minimum of seven years of professional experience. Capabilities and experience in field studies and in computer modeling of groundwater flow and solute transport is essential. Client contact experience and good writing skills, including report writing experience, are highly desirable. Position will involve work on solid and hazardous waste projects.

Jordan Gorrill Associates is a nationally recognized geotechnical consulting firm providing a wide range of services in geotechnical engineering, geology, hydrogeology, geophysics, and soil science.

Send resume to: Director of Personnel, Jordan Gorrill Associates, subsidiary of E.C. Jordan Co., 562 Congress St./P.O. Box 7060, Portland, ME 04112, (207) 775-2923.

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For further information please write to Doornbos/Husebye (for residents of Africa, Asia or Europe) or Richter/Gilbert (for residents of the Americas, Australia, and New Zealand, and island nations).

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Supervisory Geophysicist. The National Oceanic and Atmospheric Administration (NOAA) announces a Supervisory Geophysicist, GS-13, vacancy in the National Geophysical Data Center, Solid Earth Geophysics Division, Boulder, Colorado. Starting salary at GS-13 level is $34,930. Duties include administrative and technical activities on behalf of the Branch; maintaining liaison with principal geophysicists nationwide; recommending to the Division Chief new techniques and services; serving on national working groups; and providing expert advice. An advanced knowledge of theoretical and practical applications of geophysical data, e.g., gravity, geomagnetism, seismic reflection and related disciplines is required. For further information and/or application procedures, please call Mary Plumley, NOAA Personnel, at (303) 497-3102. Applications must be received by Sept. 23, 1983 to be considered.

An Equal Opportunity Employer.

Professor of Marine Geophysics Tectonics/Stanford University. The Department of Geophysics, Stanford University, is seeking candidates for a tenure track position in the broad area of marine geophysics and tectonics. We seek a creative scientist with experience in gathering, interpreting, and synthesizing marine geophysical data and wide-ranging research interests cover depositional, igneous, and tectonic processes on oceanic plates and continental margins. Inquiries are invited from marine geophysicists with demonstrated scientific record in one of the above aspects of marine geophysics or tectonics, who have demonstrated an ability to develop new ideas and research directions, and to guide and teach graduate and undergraduate students. In considering this appointment we are interested in maximizing interactions with ongoing research groups in marine geology, plate tectonics, paleomagnetism, seismology and regional geology at Stanford. Our new faculty member will be expected to develop a strong research program involving both government and industrial participation.

Salary and rank will be commensurate with experience and background. Please submit a resume, a brief description of teaching and research interests, and references to:

Dr. Amos Nur
Department of Geophysics
321 Mitchell Building
Stanford University
Stanford, CA 94305

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University of California/Assistant Researcher. Scripps Institution of Oceanography invites applications for the position of Postgraduate Researcher through Assistant Researcher. Appointment as Assistant Researcher requires a publication record. The position is in the upper ocean physics group of the Marine Physical Laboratory. Active research areas include air-sea interaction, internal wave and mixed layer studies, as well as doppler acoustic sensor design. Candidates should have a Ph.D. in Oceanography, Physics or Engineering as well as experience and a desire to participate in field research. Salary range: $15,936 to $26,000. Send curriculum vitae and names of references to Professor Robert Pinkel, Marine Physical Laboratory, Scripps Institution of Oceanography, UCSD, San Diego, CA 92152. Closing date: August 31, 1983.

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Research Positions/Lunar and Planetary Laboratory. The Lunar and Planetary Laboratory at the University of Arizona has research positions open for Research Scientists. Researchers at the Laboratory have access to the University's observatories, a wide range of astronomical instrumentation, a complete collection of planetary images, computers and laboratory facilities. The research ranks in the Laboratory, namely Assistant Research Scientist, Associate Research Scientist, and Research Scientist parallel the tenure track ranks of Assistant, Associate and Full Professor. Salary is competitive commensurate with equivalent tenure-track ranks. There are no tenurable and non-state-funded positions. Researchers in these positions will be expected to supply a significant portion or all of their salaries through their grants and contracts.

Applicants should submit a curriculum vita, list of publications, and the names of three references by November 1, 1983, to: L. Wilhelm Haas, Business Manager, Lunar and Planetary Laboratory, University of Arizona, Tucson, Arizona 85721.

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Hydrogeologist, Hydrologist, or Water Resources Planner. The Kansas Geological Survey, a division of The University of Kansas, solicits applications for a hydrogeologist, hydrologist, or water resources planner. Permanent, full-time position subject to annual review. Salary Range: $20,000–$30,000 per year, depending on qualifications. Required qualifications: Master's degree in hydrogeology, hydrology, or related water resources field. Course work in theoretical hydrologic modeling and capability to apply these models to different hydrologic and water planning problems in particular areas in Kansas. Preferred qualifications: Ph.D. degree in one of the above fields, and 2–3 years of research experience in water resources related studies.

Contact Personnel Manager, Kansas Geological Survey, 1930 Constant Avenue, Campus West, The University of Kansas, Lawrence, Kansas 66048 (Ph. 913/864-3965) for full position description, or to apply, send resume, college transcripts, list of published research, and letters of reference. Priority will be given to applications received by October 31, 1983. Applications will be accepted and reviewed every thirty days thereafter until the position is filled.

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Research Associate/Petrography-Petrology. To join a research effort aimed at understanding the sedimentation history of the solar system by mineralogical, chemical, and isotopic studies of tiny inclusions in primitive meteorites. Applicant need not have previous experience with meteorites but should be a petrographer, skilled in the use of the SEM and electron probe. Successful candidate will be dedicated, productive, an effective communicator both orally and in writing, and will have a Ph.D. in hand. Vacancy expected in mid autumn 1983.

Send resume and names of three references to L. Grossman, Department of the Geophysical Sciences, University of Chicago, 5734 S. Ellis Avenue, Chicago, IL 60637.

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Support Scientist I/II/The National Center for Atmospheric Research in Boulder, Colorado. The National Center for Atmospheric Research is recruiting for Scientist I and II for the Convective Storms Division-Mesoscale Interaction Group. DUTIES: Carries out individual and collaborative research on small to mesoscale meteorology. Projects will be selected and defined in collaboration with the senior staff. Scientific effort will focus on the structure and dynamics of convective systems, thunderstorm initiation, hurricanes, interactions among turbulence, convection, mesoscale, and synoptic scales. Emphasis is on observational studies of the planetary boundary layer, mesoscale convective systems, tethered balloons, aircraft, and Doppler radars. Actively participates at scientific meetings; makes contributions to professional journals and other literature; may participate in planning and supervision of the Stormscale Operational and Research Meteorology (STORM) field experiments and other field programs; develops an understanding of mesoscale systems that will enhance accurate forecasting; interacts with scientists within NCAR and elsewhere to achieve individual and group scientific objectives; manages employees in ways consistent with UCAR policies and procedures and Affirmative Action program goals. QUALIFICATIONS:

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• Demonstrated skill and creativity in analysis/interpretation of data from one or more of the data systems listed above with a realistic idea of their limitations

• Demonstrated skill in oral and written presentation of scientific results

• Ability to write and modify complex computer programs for data analysis

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Scientist I/the National Center for Atmospheric Research. NCAR is seeking a Scientist I for the Acid Deposition Modeling Project.

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• Ph.D. or equivalent experience and education

• Considerable knowledge of tropospheric chemistry

• Knowledge of atmospheric chemistry modeling, atmospheric scavenging processes, physics of meteorology, and computer programming.

NOTE: Scientist I appointments are for terms of up to three years. Individuals may be appointed to the next higher level of Scientist in accordance with the UCAR Scientific Appointments policy.

Salary: $25,814—$38,722/year

To apply: please send resume or call Margaretta Dowell at (303) 494-5151, ext. 517 for information and application. NATIONAL CENTER FOR ATMOSPHERIC RESEARCH, PO Box 3000, Boulder, CO 80307. Equal Opportunity/Affirmative Action Employer.

Chairman—Department of Geological Sciences, Wright State University. The Department of Geological Sciences, invites applications for the position of chairman, to be appointed September 1984. We seek a dynamic individual with administrative talent and an appreciation for research and practice-related educational activities. Rank is at the full professor level and no restrictions have been placed on areas of specialization. The department is active with faculty and an emphasis on professional practice, yet maintaining a firm commitment to basic research.

Send a letter of application, curriculum vitae and names of three references to:

Chairman, Search Committee
Department of Geological Sciences
Wright State University
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XVIII INTERNATIONAL COURSE IN GROUNDWATER HYDROLOGY. Sponsored by the Polytechnical University of Barcelona, the Catalan Private Water Authority, the Public Works Geological Service, the Hydrographic Confederation of the Eastern Pyrenees, the Spanish Foreign Office, the Generalitat of Catalonia, the Water General Secretary of Barcelona and the Public Works Study and Experimentation Center. This course will be held in Barcelona from January 16 to July 15 1984. It will be especially intended for graduates from Mathematical, Physical Sciences and science faculties who wish to receive further training or specialization in the problems of prospecting, uptake, exploitation and planning of groundwater while studying surface water and other hydrological resources.

The teaching program will be: auxiliary disciplines, groundwater prospecting, exploration and water management. There will be a total of 811 hours for the theoretical and applied courses, 9 field trips, 7 technical visits, and a ground-water practical report. Lectures will be given in Spanish.

For further information, please write to: Secretaria Internacional de Hidrologia Subterranea, Barcelona-21 (Spain), Telephone (93) 322-19-51, Telex 52455 COABNE.

AGU

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Membership Applications Received

Applications for membership have been received from the following individuals. The letter after the name denotes the proposed primary section affiliation.

Frank W. Bergstrom (H), John A. Best (S), Lawson W. Brigham (O), Jan Olof Burgman (H), Dominique Burrus, John S. C. Curran (G), Daniel Davies (P), Michael P. Dumont (O), Gerald R. Garrison (O), Varut T. Guvanasen (H), Ross N. Hollman (A), Bonnie Jones, Lubitchi L. Kostov (H), Paul Lagace, James M. Lattimer (SS), Duncan T. Mackenzie (SI), Franz X. Meixner (A), Jacques Merle (O), Kichang Na (V), Alan E. Rufty (G), Susan L. Russell-Robinson (V), Rick Sumerfe (G), Minoru Suzuki (G), Bernard Shizgal, Don Vrobleskv (H), Craig B. Waff (P), Julia A. Watts (A), Grayson Yapp (V).

Student Status

Jeffrey Alexander (O), Sang Keun Bae (H), Ronald L. Biegel (S), David A. Bouess (S), Robert S. Borch (V), Eric J. Brown (S), Randie E. Cabeen (H), Diane H. Carlson (V), Everett F. Carter (O), David Dahl (V), Gene M. Davis (V), Edward F. Duke (V), Cheryl Lyn Dybas (O), Tracy Eanes (O), David Graham (V), Joseph Ha (S), Remy Hennet (V), Katherine Hirschboeck (H), Austin Intlenwarrin (GP), Todd Allen Klug (S), Michael Leonard (S), Ellen Lettvin, Gad Levy (A), Stanley D. Locker (O), Subhashis Mallick (SI, Teruyuki Matsui (T), Michael McKibben (V), Herbert W. S. McQueen (T), Javier J. Meneses-Rocha (T), David J. Mulla (H), Patrick M. Okita (V), Carol Prentice (T), Margaret P. Ricri (S), Daniel Rosenblatt, Daniel Rothman (S), J. Michael Ruotoniemi (SA), Bradford Sherman (H), Van Soug (V), Stephen W. Todoroff (O), E. A. Vaverka (GP), Richard Wagener (P), E. Timothy Wallis (GP), Eldean M. Ward (T), Douglas A. Wolf (V).

Union and Section Candidates

In the coming months *Eos* will carry biographies and photographs of all candidates for President-elect, General Secretary, and Foreign Secretary of the Union and for President-elect and Secretary of each Section. In addition, statements by the candidates for Union offices and Section President-elect will appear. The material for the Geodesy, Geomagnetism and Paleomagnetism, and Planetology sections appears below. The slate of candidates for all offices was carried in *Eos*, June 21, 1983, p. 422.

Geodesy: President-elect

John D. Bossler A member of AGU since 1972; 46 years old; Chief, National Geodetic Survey, Charting and Geodetic Services, National Ocean Service, National Oceanic and Atmospheric Administration (NOAA) of the Department of Commerce; Major interests: Geodetic Science and Surveying, B.S. in Civil Engineering, University of Pittsburgh (1959); M.S. in Geodetic Science, Ohio State University; was concurrently Project Manager for the New Adjustment of the North American Horizontal Geodetic Datum and Deputy Director, National Geodetic Survey. His scientific experience includes developing algorithms and computer programs and performing research in support of various projects in geodesy and geodynamics. Vice President, American Congress on Surveying and Mapping; Secretary, AGU Geodesy Section; Past Chairman, American Society of Civil Engineers, Executive Committee of the Surveying and Mapping Division; Secretary, Section I (Control Surveys), International Association of Geodesy; Member, U.S. National Committee of the International Union of Geodesy and Committee on Geodesy; 98 publications, 3 published by AGU. Recipient of two Heiskanen Awards of Ohio State University and recipient of the 1982 Department of Commerce Gold Medal (the Department's highest award). Past Associate Editor, *Journal of Geophysical Research*.

Statement

"Geodesy lies at the center of a spectrum of technical disciplines ranging from ones that emphasize geometry, like cartography, surveying and photogrammetry, to those that are based on physics, like oceanography and seismology. This central focus means that geodesy is well positioned to influence (and be influenced by) a most diverse group of scientific fields. As part of AGU, the Geodesy Section has tended to concentrate on the physical side. In recent years, this interaction has proved very fruitful, because increasingly precise geodetic measurements and techniques have shed much light on significant areas of geophysical research. I believe that geodesy should and will continue to serve as a productive source of information for the rest of geophysics. Therefore, I would push for closer and more formal cooperation between the Geodesy Section and other AGU sections in setting up AGU meeting programs, special symposia, and in AGU publications, e.g., the Special Issues of JGR. We should combine sessions and develop specialty conferences with other sections to further strengthen these ties.

"But I would also stress that the Geodesy Section must not neglect its relationships on the geometric side. The new, precise positioning techniques—GPS, VLBI, laser ranging, and inertial positioning—not only yield valuable geodynamical information, but also provide surveyors with tools that can revolutionize their profession. The Geodesy Section must be holistic in its attitude and embrace all the disciplines within its purview. We must enlarge our contact with kindred societies like the American Congress on Surveying and Mapping and the American Society of Photogrammetry. Furthermore, we should strive to influence educational institutions to combine courses which relate to these various aspects of geodesy but are usually widely separated departmentally. I would see to it that AGU actively sponsors or cosponsors meetings and symposia featuring geometric geodesy and geodetic instrumentation. Thus, I maintain that geodesy must develop in both directions—physical and geometric—and that such development will optimally benefit our profession and the scientific community in general.

"I am particularly concerned that geodesy not lose sight of the fact that it is a science in its own right, and not just a service to other sciences. The fundamental geodetic objectives—to determine positional relationships and the gravity field—remain unchanged and continue to be interesting and important areas for scientific investigations. Geodetic research will maintain its usefulness for other sciences, but those who engage in this research are first and foremost geodesists and should be proud to wear the title."

Geodesy: Secretary

William E. Carter A member of AGU since 1980; 43 years old; Chief of the Advanced Technology Section, Geodetic Research and Development Laboratory and VLBI Project Manager, National Geodetic Survey. Major interest: the application of advanced technology to geodetic surveying for research in geodynamics, e.g., the use of Very Long Baseline Interferometry and Lunar Laser Ranging to study polar motion, earth rotation, and motions and deformations of the lithospheric plates. B.S. in Civil Engineering, University of Pittsburgh, 1961; M.S. in Geodetic Science, Ohio State University, 1965; Ph.D. in Civil Engineering, University of Arizona, 1973. Geodetic Officer in U.S. Air Force, 1961–1969; Research Geodesist, Air Force Cambridge Research Laboratory Lunar Laser Ranging Observatory 1969–1978; Research Associate and Head of the Lunar Laser Ranging Observatory, University of Hawaii, 1973–1976; National Geodetic Survey, 1976–present. Member of IUGG; President of IAG SSG 2.51 on Radio Interferometry; Member Steering Committee of Commission VIII on International Coordination of Space Techniques for Geodesy and Geodynamics; Member of IAU; Principal Coordinator of VLBI on MERIT Steering Committee; Member AAS. 40 publications, 5 published by AGU, including "Frequency modulation of the chandlerian component of polar motion," and "Refinements of the polar motion frequency modulation hypothesis."

Petr Vaníček Member since 1978; 47 years old; Professor of geodesy, University of Toronto (Erindale College) and University of New Brunswick, Fredericton. Current research interests: geodynamics, earth gravity field, mathematical techniques of geodesy, application of statistics in geodesy, applications of extraterrestrial methods to geodesy, physical oceanography, theoretical elasticity. Received Dipl. Ing. degree in geodesy (1959) from the Czech Technical University, Prague, and Ph.D. in mathematical physics (1968) from the Czechoslovak Academy of Sciences, Prague. Worked as a surveyor at Prague Institute of Surveying and Cartography (1959–1968); consultant in numerical analysis and computer applications at Faculty of Technical and Nuclear Physics of Czech Technical University (1968–1967); research fellow and later senior scientific officer at Institute of Oceanography, Bidston, UK (1967–1969); NRC of Canada postdoctoral fellow in Surveys and Mapping Branch of EMR, Ottawa (1969–1971); associate and full professor of geodesy at UNB (1971–1983); visiting scientist, USGS Center for Earthquake Research, Menlo Park, California (1977). Currently: member of executive CGU; fellow of GAC; Sigma Xi; member of CIS, NYAS, SWU; member of Canadian National Committee for IUGG; Committee on Geodesy of NAS-NRC. Author of 140 books and papers including 3 papers in *Eos* (e.g., "The map of contemporary vertical crustal movements in Canada," with D. Nagy) and one in *Reviews of Geophysics and Space Physics* ("Geodetic levelling and its applications," with R. O. Castle and E. I. Balazs). Co-editor of *Manuscripta Geodaetica*. Member of the IAG working group nos. 1.21, 1.41, 4.60, 5.83. Canadian representative on IUGG Committee on Recent Crustal Movements. Honors include: NERC (UK) Senior Research Fellowship (1967–1969); NRC (Canada) Postdoctorate Fellowship (1969–1971); CNPq (Brazil) Visiting Professorship (summers 1975, 1976, 1979); NRC (USA) Senior Visiting Scientist (1978); University of Stuttgart (W. Germany) Visiting Professorship (summers 1981, 1982); University of Sao Paulo (Brazil) Visiting Professorship (summer 1981). 1978 to 1981 served on AGU GMP Committee.

Statement

"North American geodesy has been suffering from a lack of identity. This continent has seen some of the most spectacular geodetic achievements; yet, often enough these were born under the auspices of space science, tectonophysics, oceanography, etc. Some of my more pragmatic colleagues will argue that there is nothing wrong with this, "throw out plurality." I feel, however, that the cause of science would be better served if geodesy were, once more, recognized for what it is: a scientific discipline in its own right.

"Geodesy is the discipline that concerns itself with the geometry of the earth and its gravity field, including the temporal variations thereof. This geodesy is as much a part of geophysics as geometry is a part of physics. It is on these philosophical foundations that the Geodesy Section should cooperate with the other sections of AGU. It is this position that the Geodesy Section should take when asking itself: What is there that the geodesy can do for the other disciplines and what is there the other disciplines can do for geodesy? It is this point of view that I should adopt if elected to the presidency.

"On a more down-to-earth level, the Section may consider doing more for the promotion of AGU among professional colleagues and students alike. The promotion should include soliciting research papers as well as review papers for JGR and RGSP, and soliciting manuscripts for publication in the AGU Geophysical Monograph Series. As an example of other possibilities, the Section may consider launching a campaign to evaluate geodetic content in various pertinent university programs on this continent and publish the results.

"To conclude, I should like to thank the Nominations Committee for the honor bestowed upon me by having nominated me even though I am not a U.S. citizen."

AGU (cont. on p. 528)

AGU (cont. from p. 527)

James G. Marsh A member of AGU since 1971. Employed in the Geodynamics Branch, Goddard Space Flight Center, since 1984. Major interests: precision orbit determination, geodetic parameter estimation, and applications of satellite altimetry data to the determination of mesoscale and global circulation. Received NASA Exceptional Service Medal in 1980. Published over 70 papers. M.S. in Physics, West Virginia University 1968.

Geomagnetism and Paleomagnetism: President-elect

Subir K. Banerjee A member of AGU since 1967; 45 years old; Professor of Geophysics, University of Minnesota, Minneapolis. Major interests: geomagnetism, paleomagnetism, rock magnetism, and history of medieval science. B.Sc. in physics, Calcutta University, 1956; M. Tech in exploration geophysics, Indian Institute of Technology, Kharagpur, 1958; Ph.D. in geophysics, Cambridge University, 1963. Senior Research Associate and lecturer in geophysics, University of Newcastle-upon-Tyne, UK, 1964–1968; Senior Staff Scientist, Franklin Institute Research Laboratories, Philadelphia, 1968–1971; Associate Professor of Geophysics, University of Minnesota, Minneapolis, 1971–1974; Professor of Geophysics at Minnesota since 1974. Adjunct Professor of Middle Eastern and Islamic Studies at Minnesota since 1976. Visiting Professor at different times at Osmania University, India, Stanford University, and University of California, Berkeley. Visiting Scholar, Office for History of Science and Technology, University of California, Berkeley, 1977–1978. Past member of Institute of Physics, UK and European Physical Society. Editorial Board: Quaternary Research, 1978–1980. Past member, U.S. Geodynamics Committee, Working Group on paleomagnetism; Vice-Chairman and U.S. representative in International Association of Geomagnetism and Aeronomy, Working Group on rock magnetism, 1975–1979; NRC-NAS Study Panel on Impact of Technology on Geophysics; Member, Program Committee for USGS Workshop on Geomagnetism, 1982; 90 publications, 12 published by AGU; author of *Physical Principles of Rock Magnetism* (with F. D. Stacey); Sc. D., Cambridge University; listed in Who's Who in America, and American Men and Women in Science; served as Associate Editor, *Journal of Geophysical Research* Reil, and *Reviews of Geophysics and Space Physics*; presently a member of the AGU Committee on the History of Geophysics; Program Chairman, Geomagnetism and Paleomagnetism section, 1983 AGU Fall Meeting.

Statement

"I thank the nominating committee for the opportunity to be considered as one of the candidates for the presidency of the section. The president of the GP section has a two-fold responsibility: first, toward the membership at large, and second, to the AGU Council by acting as a two-way channel for communications. I propose to pursue vigorously both of these activities, some by continuing the excellent approaches initiated by the present president and president-elect and by initiating a few of my own.

"The membership at large has justifiably been concerned by the splitting of the national meetings into two de facto regional meetings. In 1968, the year when GP was created as an autonomous section, there were 61 papers delivered at the spring meeting and 11 at the fall meeting. In 1982 these numbers were 59 and 112, respectively! It is hard to buck the sentiment of the membership "voting with their feet," but it is well within our capability to work with the two section program chairpersons so that special sessions of broad national interest are alternated between the two meetings and to schedule occasional workshops of broad interest in the membership at large (such as the Rock Magnetism Workship that I have arranged for the 1983 Fall Meeting). In this connection, if elected, I propose to use vigorously the topical Chapman conferences to bring together smaller groups of workers in GP section with similar or complementary interests, as was done at the 1982 USGS Workshop on Geomagnetism in Golden, Colorado.

"A second service to members is through the journals program. Following the lead of the Ocean Sciences Section, and now the Volcanology, Geochemistry, and Petrology section, I propose to publish in *Eos* from time to time a GP newsletter which will inform the membership about new researches, funding sources, instrumental developments, and, above all, about mechanisms to keep in close touch workers in electromagnetic induction studies, main field studies, paleomagnetism, and rock magnetism. Another area where I could be of service to GP members is by cooperating with the new editors of GRL and RGSP so as to increase the present minuscule percentage of articles dealing with geomagnetism and paleomagnetism in these journals.

"There has always been a conscious effort to involve "new blood" in participating in the GP section affairs, and I myself have been a beneficiary of this in the past. I propose to pursue this tradition thoroughly be it by inviting contributions from new authors for the IUGG Quadrennial Report, or by nominating new faces as conveners for special sessions at the national meetings, and especially by making sure that an ever-increasing number of younger workers are given travel grants to attend IAGA and IUGG assemblies.

"If I am able to carry out at least some of the above initiatives and inform the AGU Council accordingly, our voice in the Council will be heard loud and clear. In addition, I will also seek out membership concerns about the AGU as a whole, to be voiced at the Council meetings, and cooperate with the other section presidents for the furtherance of the goals of AGU."

D. Ian Gough A member of AGU since 1964; age 60; Professor of Physics, University of Alberta. Major interests: solid earth geophysics and tectonics, with emphasis on electromagnetic induction in earth and its use in delineating tectonically significant structures; paleomagnetism; induced seismicity and lithosphere stress. B.Sc. in physics and mathematics, Rhodes University, South Africa, 1943; M.Sc., 1947; Ph.D., University of Witwatersrand, 1953, South African National Physical Research Laboratory 1947–1958; University College of Rhodesia and Nyasaland 1958–1963; Southwest Center for Advanced Studies, Dallas 1964–1966; University of Alberta, professor from 1966, Director, Institute of Earth and Planetary Physics, 1975–1980. Fellow: Royal Society of Canada, AGU, Royal Astronomical Society, Geological Association of Canada; Hugh Kelly Fellow, Rhodes University, 1947; Visiting Fellow, Churchill College, Cambridge, UK 1978. Former President, CGU. Has served on numerous Canadian national committees, currently member of Canadian National Committee for the International Lithosphere Program and of Lithoprobe Steering Committee. Chairman, Division I, IAGA. 80 publications, 13 published by AGU. Formerly Associate Editor, JGR; on editorial boards of *Journal of Geomagnetism and Geoelectricity, Physics and Chemistry of the Earth, Journal of Geodynamics.*

Statement

"A prospective president of a section of AGU must be able to arrange timely sessions and workshops on topics in which the science is advancing. I must tell you how I see Geomagnetism and Paleomagnetism at this time, so that you may judge whether I might be an adequate president of the GP Section.

"The description of the geomagnetic field has recently made great strides by means of satellite data for the latitude range 30°N to 30°S. The development of periodically updated international geomagnetic reference fields both improves the data base for workers on the core field and facilitates good maps of the crustal anomaly field. In high latitudes both steady and transient currents in the magnetosphere and ionosphere can be studied by satellites in polar orbits, but obscure the internal field from the core and crust. High latitude satellite magnetic data thus present difficult problems but certainly contain information of great value.

"For those working on the core dynamo problem I think interaction with paleomagnetists is important. Paleomagnetic data have shown that the core field has been dominantly dipolar through the last 5Ma or so and confront the dynamo theorists with aperiodic reversals. Data for the field during a reversal are vital but few. Intensity data are now accumulating and give further input to the dynamo problem. The paleomagnetists themselves are increasingly studying the geomagnetic field rather than plate kinematics. In addition to finding paleo-intensities they are using recent sediments, from lakes in particular, to investigate the nondipole field over the last few millenia. In hard-rock paleomagnetism the correct separation of multiple components of remanent magnetization presents a problem. For precambrian rocks accurate dating and definition of the paleodiurnal are problems often harder than the paleomagnetic measurements themselves.

"Those concerned with the use of electromagnetic induction to show conductive structure confront ever-increasing data but no matching advance in inversion techniques. The combination of magnetometer arrays with magnetotellurics is being tried and may prove fruitful. Various artificial sources of magnetic fields are in use and will simplify inversion. Ocean-floor data are beginning to open new opportunities. Even without quantitative modeling, electromagnetic data often reveal and locate structures of geotectonic significance.

"In the era of interplanetary vehicles, magnetic field data from other planets must fascinate us all. AGU will undoubtedly continue a leading role in the study of the magnetospheres of the Jovian planets in conjunction with that of the earth. Work on the solar wind and magnetic field, and their interaction with planetary magnetospheres, is active and important.

"These are some fields in which I see growth at the present time. My list is certainly incomplete. If your field is unmentioned or travestied and I am elected, it will be up to you to make good the gap in my education."

Geomagnetism and Paleomagnetism: Secretary

John W. Hillhouse A member of AGU sinre 1972; 34 years old; geophysicist, U. S. Geological Survey. Major interests: paleomagnetism, solid earth geophysics, and plate tectonics. A.B. in geology and geophysics, University of California, Berkeley, 1971; Ph.D. in geophysics, Stanford, 1975. With USGS since 1974. Member: AGU, GSA; 15 publications, 5 published by AGU. Phi Beta Kappa. Served as Fall Meeting program cheirman of GP section; associate editor of JGR red.

John L. LaBrecque A member of AGU since 1973; 36 years old. Presendy a Senior Research Associate at the Lamont-Doherty Geological Observatory and a member of the Columbia University Faculty. Received his B.S. from the Columbia School of Engineering in 1969, M.Ph. and Phil. from Columbia in marine geophysics in 1973 and 1977 respectively. In 1981 served as research associate at the Laboratorio di Geologia Marina of the Italian CNR at Bologna. Has over 22 publications, which include studies of the geomagnetic reversal history, the South Atlantic, Indo-Atlantic and Red Sea Basins, investigations of intermediate wavelength magnetic anomalies over the North Pacific, and the development of passive continental margins. Has served the DSDP both as a member of the Southwest Atlantic working group and a co-chief scientist aboard Leg 73 of the Glomar Challenger during an extremely successful application of HPC technology to magnetostratigraphy. Currently conducting active research in the geologic implications of intermediate wavelength magnetic anomalies, Antarctic and South Atlantic plate kinematics, and the magnetic anomaly patterns over transition zones at passive continental margins. Also active in areas of satellite data analysis including the NAVSTAR, MAGSAT, and SEASAT data sets.

Planetology: President-elect

Michael H. Carr A member of AGU since 1965; 47 years old; Geologist with the U.S. Geological Survey. Major interests: general geology of the planets; planetary volcanism; history of fluvial processes and volatiles on Mars. B.Sc. in geology, University College, London, 1956; Ph.D. in geology, Yale University, 1960. Research associate, University of Western Ontario, 1960–1962; with the U.S. Geological Survey since 1962; Chief, Branch of Astrogeologic Studies, 1974–1978. Member: AGU, GSA, AAAS. 83 publications, 14 published by AGU; author of *The Surface of Mars* published by Yale University Press. Served on several advisory committees to NASA: Lunar and Planetary Review Panel; Planetary Geology Review Panel, Planetary Geology Working Roup, NAS-Committee for Planetary Exploration. Leader Viking Orbiter Imaging Team; member Mariner 9, Voyager, and Galileo science teams. Associate editor *Icarus*, associate editor JGR Red. NASA medal for Exceptional Scientific Achievement, 1977; Department of Interior Meritorious Service Award, 1980.

Statement

"The last few years have been both exhilarating and discouraging for planetary science. Missions to Venus, Mars, Jupiter, and Saturn have been spectacularly successful, but funding for research and analysis has declined, and new missions, the lifeblood of the science, have been difficult to initiate. The rate of acquisition of new data has slowed considerably and will remain at a low level for at least 5 years. However the outlook now appears to be changing. The long decline in research funding has been arrested, if not reversed, and a new philosophy for design of planetary missions, outlined by NASA's Solar System Exploration Committee, has led to optimism about the feasibility of sustaining a sound program of scientific exploration of the planets despite tight fiscal constraints. This optimism appears justified in view of recent approval of a Venus Radar Mapper mission and supplements to NASA's planetary exploration budget.

"These developments have several implications for the Planetology Section of AGU. The pause in data taking should lead to a maturation of the science. For most planetary bodies the reconnaissance has been done and the initial, quick interpretations have been made. Now is the time for consolidation, for integration of the results from different disciplines, and for a more thorough and exhaustive analysis of the data in hand. Such a period of reassessment is not only desirable for the health of the science but is also necessary for a balanced, ongoing exploration program. Because of the fiscal constraints, future missions will probably be much more narrowly focused than past missions. They will tend to address a limited number of specific problems rather than the science of a planet as a whole. We then must be in a position to judge which are the most pressing problems and what measurements must need to be made. AGU, being the major multidisciplinary organization for planetary scientists, can play a significant role in this process of maturation, and that role should be promoting the highest possible standards for planetary science. Ways that this might be achieved are by maintaining the traditionally high standards of publication in AGU, by holding at AGU meetings multidisciplinary sessions on various topics of broad interest, and by providing a forum for presenting the results of planetary science to the general scientific community. AGU has recently started to play a larger role in planetary science by publishing the proceedings of the Lunar and Planetary Science Conferences. I would like to see it play an even larger role by having the Lunar and Planetary Science Conference held less frequently and encouraging more presentations at the meetings of professional societies such as AGU."

Seen G. Solomon A member of AGU since 1967, a Fellow since 1980; 37 years old. Professor of Geophysics, Massachusetts Institute of Technology. Major interests: planetary tectonics, seismology. B.S. in geophysics, California Institute of Technology, 1966; Ph.D. in geophysics, MIT, 1971. On MIT faculty since 1972. Visiting Faculty, UCLA, and Visiting Scientist, Jet Propulsion Laboratory, 1982–83. Member: AAAS, SSA. Has served on the NAS-NRC Space Science Board and its Committee on Planetary and Lunar Exploration, and has chaired its Committee on Earth Sciences. Has also served on the Lunar Sample Analysis Team, VOIR Science Working Group, USRA Lunar and Planetary Science Council, and Lunar and Planetary Review Panel. Currently serves on the Venus Radar Mapper Project Science Group, Geopotential Research Mission Science Steering Group, Crustal Dynamics Working Group, Planetary Geology Working Group, and Joint U.S.-European Working Group for Planetary Exploration. About 80 publications, 30 in AGU journals. NSF Graduate and Postdoctoral Fellow; Hertz Foundation Fellow; Sloan Research Fellow; Guggenheim Fellow. Past Associate Editor, JGR and *Eos*; currently on AGU Geophysical Monograph Board.

Statement

"Planetology within AGU faces several obstacles not shared by the other sections. The field is uniquely diverse; since the earth is obviously a planet, one might even argue that all of the disciplines represented within AGU fall under the planetology heading. Planetologists, defined in the more conventionally limited sense, must also split their loyalties among several organizations, of which AGU is just one. This divided loyalty is particularly severe for meetings; many planetary scientists choose to present their most important results at the DPS meeting or the Lunar and Planetary Science Conference rather than at one of the AGU national meetings.

"What, then, should be the role of AGU in planetary science and of the Planetology Section within AGU? The primary objective of AGU is scientific communication, both among its members and between the Union and the public, including our scientific peers in other fields. AGU, therefore, can serve two roles for planetary science. It is a focus for planetary scientists, probably the broadest-based organization of its kind in the field. And it can foster communication of the discoveries and excitement of planetary science, and indeed all of geophysics, to the rest of the nation. The Planetology Section should play the largest part in the latter task, and has the additional role of keeping the other sections up to date on the most important new results in solar system science.

"The national meetings of AGU are not likely to preempt the DPS meeting or LPSC as the principal meeting at which planetary scientists share new results with each other. The national meetings should rather be used as a forum to organize informative general sessions and to cosponsor with other sections special sessions on topics that span section interests. A recent session dealing with a comparison of the tectonics on Venus and the earth as a guide to the role of plate tectonics in planetary evolution is one good example in the latter category. Joint lunchtime functions with the VGP Section is another. AGU should also act as cosponsor for other meetings in planetary science. The cosponsorship of the Lunar and Planetary Science Conference and the publication of the Proceedings as a supplement to JGR is a laudable, large step in this direction; but AGU involvement could be extended to smaller topical meetings as well.

"AGU's publications in planetary science (JGR, RGSP, GRL) are very strong and should stay that way. In *Eos*, most news of interest to the planetary science community is communicated rapidly and effectively, largely through the efforts of Peter Bell and the *Eos* news staff. Greater use of *Eos* could be made by the Planetology Section, however, for meeting announcements and post-meeting reports. An effective approach taken by the Ocean Sciences and VGP sections is to appoint an Editor to organize and publish section reports in *Eos* on a regular basis.

"The next 5 years will see a restoration of exciting new discoveries in planetary science. In 1986 Voyager will fly by the Uranus system, and Comet Halley will be visited by ESA, Soviet, and Japanese spacecraft; in 1988 Galileo will enter Jupiter orbit, and VRAI will begin providing high-resolution radar images of the Venus surface. It will be a time when the Planetology Section should continue to play its vigorous role within AGU."

Planetology: Secretary

Raymond E. Arvidson A member of AGU since 1972; 35 years old; Associate Professor, Department of Earth and Planetary Sciences, and Fellow, McDonnell Center for the Space Sciences, Washington University. Major interests: planetary surfaces, remote sensing, data management. B.A. in Earth Sciences, Temple University, 1968, Ph.D. in Geological Sciences, Brown University, 1974. Faculty member at Washington University since 1974. Former Chairman, Extraterrestrial Sciences Committee, American Society of Photogrammetry. Chairman, Committee on Data Management and Computation, and member of Space Science Board, National Academy of Sciences. Member of several NASA advisory groups. 54 publications, 14 published by AGU. Associate Editor of *Journal Geophysical Research.*

H. J. Melosh A member of AGU since 1975; 35 years old; Associate Professor of Planetary Science at the Lunar and Planetary Laboratory, University of Arizona. Major interests: the mechanics of impact cratering, planetary tectonics, and the application of physical principles to geologic processes. A.B. in physics from Princeton University in 1969; Ph.D. in theoretical physics from Caltech in 1973. Postdoctoral Fellow at the Enrico Fermi Institute of the University of Chicago, 1973–74; Instructor, Assistant Professor, and Associate Professor at Caltech 1974–79; Associate Professor at SUNY, Stony Brook until 1982. Member: Sigma Xi. Served on LPRP (NASA) and is presently on COMPLEX (NAS-NRC); 44 publications, 18 published by AGU.

Meetings

Announcements

Geology Meeting

The Association of Engineering Geologists will hold its 26th Annual Meeting in San Diego, Calif., October 3–8, 1983. The program will include technical sessions on hazardous waste and hydrogeology, seismicity and faulting stability, landslides and slope stability, and construction and engineering geology. Symposia on engineering geology; mapping symbols; resources exploration, development, and reclamation; rock logging; hydrogeology; engineering geophysics; and the Coalinga earthquake are also on the schedule.

Several field trips will be offered, including one featuring the geology of urban San Diego and short courses on the applications of soil stratigraphic techniques for engineering geologists and on landslide hazards and their reduction will be available.

For more information contact Dong Sing, Chairman, Registration Committee, c/o Woodward-Clyde Consultants, 3467 Kurtz St., San Diego, CA 92110 (telephone: 619-224-2911) or John Foster, Chairman, Exhibitors' Committee, c/o Wahler Associates, 2007 Quail St., Newport Beach, CA 92660 (telephone: 714-540-5905).

Planetary Plasmas

A conference sponsored by NASA entitled The Planetary Plasma Environment: A Comparative View will be held January 28 to February 3, 1984, in Yosemite, Calif. The preliminary program includes sections on the comparison of plasma sources and energization processes that exist in the inner and outer planets as well as in comets; internal sources of plasma and ionospheric-magnetospheric coupling in planetary systems; ionospheric processes that serve as the source of ions and the plasma processes by which these plasmas are energized; external sources of plasma and energy from both the solar wind and planetary satellites; and the effects of these plasma and energy sources on the composition and dynamics of the planetary magnetospheres. Because of the breadth and complexity of the conference topics, sections will focus on a few carefully selected examples of the processes under discussion.

A large number of invited papers are already on the agenda. The number of conference attendees will be limited to 100.

For more information contact the cochairmen of the conference, J. H. Waite of the NASA/Marshall Space Flight Center (telephone: 205-453-3087 or 3040) or C. F. Kennel of Stanford University (telephone: 415-497-4691). P. M. Banks, G. R. Chappell, and A. F. Nagy are the cochairmen.

Remote Sensing

An international symposium on advancements in remote sensing of land by satellite will be held in Sioux Falls, S. D., October 4–7, 1983. Topics of discussion will include remote sensing developments by the leading countries in the field, the proposed sale of U.S. remote sensing satellite operations to the private sector, U.S. policy on government research and development for future sensor systems, space shuttle remote sensing projects, and developments in research on alternative approaches and on support systems. The symposium, the eighth in a series, honors the memory of William T. Pecora, a pioneer in the field.

The proceeding's highlights include detailed presentations on Landsat 4 data characteristics and on the technology and the data distribution plans for the French satellite Le Système Probatoire d'Observation de la Terre (SPOT). Landsat 4 is a new generation remote-sensing satellite launched last July and operated by the National Environmental Satellite, Data, and Information Sevice of the National Oceanic and Atmospheric Administration (NOAA).

For more information write PECORA VII, P. O. Box 80937, Sioux Falls, SD 57116, or call the Public Affairs and Technical Information Office at the Earth Resources Observations Systems Data Center (telephone: 605-594-6114). The U.S. Geological Survey, the National Aeronautics and Space Administration, and NOAA are cosponsoring the symposium.

Marine Environment

The 18th Annual Congress of the Canadian Meteorological and Oceanographic Society (CMOS) and the 11th Annual Meeting of the Canadian Geophysical Union (CGU) will be held joindy in Halifax, Nova Scotia, May 29 to June 1, 1984. With a theme of The Marine Environment: Atmosphere, Ocean, and Lithosphere, joint sessions will deal with such topics as geophysical dynamics: atmosphere, orean, and lithosphere; Arctic expeditions: CESAR, LOREX, and FRAM; scientific services to the offshore industry; climate change; coastal meteorology; oceanography and geophysics; and boundary processes.

Abstracts, not to exceed 400 words, for papers on any topic in meteorology, oceanography, or geophysics will be accepted until January 27, 1984. Send submissions to S. D. Smith (CMOS) or H. R. Jackson (CGU), Bedford Institute of Oceanography, P.O. Box 1006, Dartmouth, Nova Scotia B2Y 4A2, Canada.

Exhibits in the fields of oceanography, meteorology, and geophysics will be on display. For more information about the exhibits contact John Brooke, 24 Flamingo Drive, Halifax, Nova Scotia B3M 1S7, Canada (telephone: 902-443-2932).

AAAS Meeting

The 65th Annual Meeting of the American Association for the Advancement of Science (AAAS), Pacific Division, will be held June 10–15, 1984, in San Francisco, Calif. During this meeting the American Meteorological Society and Section W (Atmospheric and Hydrospheric Sciences) of the Pacific Division of the AAAS will cosponsor sessions.

Abstracts for papers to be presented at the conference must be submitted by March 31, 1984, to the program chairman, John Lier, Department of Geography, California State University, Hayward, CA 94542 (telephone: 415-881-3193). The abstracts should be typed on a standard-sized sheet of bond paper and the camera-ready title and text (without paragraphs) and should fit inside a 5-inch-square (12.5-cm-square) box. A 1-inch (2.5-cm) margin should be maintained to the left of the box. Special symbols and signs that are hand-lettered should be rendered in reproducible black ink. Include the author's name, affiliation, and address at the bottom of the page. These abstracts will be published in a booklet for distribution to conference registrants.

For additional information about the conference contact Alan E. Leviton, Executive Director, AAAS Pacific Division, California Academy of Sciences, Golden State Park, San Francisco, CA 94118 (telephone: 415-752-1554).

Nonmembers of AAAS are encouraged to attend.

Rural Water

The Program Committee of the International Water Resources Association (IWRA) is soliciting papers for the Fifth IWRA World Congress to be held June 9–15, 1985, in Brussels, Belgium. In order to reflect the meeting's theme of Water Resources for Rural Areas and Their Communities, the papers should deal with such topics as the social and cultural aspects of water usage, education in and transfer of water technology, management and financing of water facilities, equipment and material, assessment and monitoring of water resources, water treatment, alternative energy sources, legal and public health aspects, management of integrated water projects, and management of water resources in disaster areas. Case studies of private practitioners are welcome. The official languages of the conference are English, Spanish, and French.

Authors interested in presenting papers at this conference should submit five copies of one-page abstracts, not to exceed 50 lines, to Fifth World Congress On Water Resources, c/o International Conference Centre, Parc des Expositions, Tentoonstellingspark, B-1020 Brussels, Belgium (telephone: 32-2-478-48-60; telex: 25-843). The deadline for submissions is September 30, 1983.

Geophysical Year

Boldface meeting titles indicate meetings sponsored or cosponsored by AGU. A list of organization abbreviations used in the list appears below.

Future AGU Meetings:

Fall Meetings
Dec. 5–10, 1983, San Francisco

Spring Meetings
May 14–18, 1984, Cincinnati
May 27–31, 1985, Baltimore

Abbreviations

AAAS American Association for the Advancement of Science
AAPG American Association of Petroleum Geologists
ACS American Chemical Society
AIPG American Institute of Professional Geologists
AMS American Meteorological Society
ASCE American Society of Civil Engineers
AWRA American Water Resources Association
GSA Geological Society of America
IAG International Association of Geodesy
IAGA International Association of Geomagnetism and Aeronomy
IAHS International Association for Hydrological Sciences
IAMAP International Association of Meteorology and Atmospheric Physics
IAPSO International Association of Physical Sciences of the Ocean
IASPEI International Association of Seismology and Physics of the Earth's Interior
IAVCEI International Association of Volcanology and Chemistry of the Earth's Interior
ICSU International Council of Scientific Unions
IUGG International Union of Geodesy and Geophysics
IUGS International Union of Geological Sciences
IWRA International Water Resources Association
MSA Mineralogical Society of America
SEG Society of Exploration Geophysicists
SEPM Society of Economic Paleontologists and Mineralogists
URSI International Union of Radio Science
WMO World Meteorological Organization

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Sept. 5–9 46th Annual Meteorlical Society Meeting, Mainz, Germany. (Friedrich Begemann, MPI für Chemie, Postfach 3060, D-6500 Mainz FRG.)

Sept. 5–9 20th International Congress of the International Association of Hydraulic Research (IAHR), Moscow, USSR (Organizing Committee of the 20th IAHR Congress, Institute "Hydroproject," Volokolamskoe Chaussee 2, Moscow A-80, 125812, USSR.)

Sept. 5–9 Pentose Conference on Bluecklists and Related Ecloptes, Bellingham and Seattle, Wash. Sponsor, GSA; (E. H. Brown, Dept. of Geology, Western Washington Univ., Bellingham, WA 98225, or B. W. Evans, Dept. of Geological Science A-20, Univ. of Washington, Seattle, WA 98195.)

Sept. 7–10 AIPG Annual Meeting, Jackson Hole, Wyo. (Gene R. George, General Chairman, P.O. Box 2775, Casper, WY 82602; tel.: 307-265-9199.)

Sept. 11–14 Disribution System Symposium, Birmingham, Ala. Sponsor, American Water Works Association. (AWWA, 6666 West Quincy Ave., Denver, CO 80235; tel.: 303-794-7711.)

Sept. 12–14 National Water Well Association 88th Annual Convention and Exposition, St. Louis, Mo.

Meetings (cont. on p. 530)

Meetings (cont. from p. 529)

Mo. (NWWA, 500 West Wilson Bridge Rd., Worthington, OH 43085.)

Sept. 12–16 International Water Supply Association Exhibition and Conferences, Brussels, Belgium. (IWSA Secretariat, 1 Queen Anne's Gate, London SW1 9BT, United Kingdom.)

Sept. 12–16 International Symposium on Isotope Hydrology in Water Resources Development. (IAEA, P.O. Box 100, Vienna International Centre, A-1400, Vienna, Austria.)

Sept. 13–14 12th Annual Conference of the Illinois Department of Energy and Natural Resources on Illinois Climate: Trends, Impacts, and Issues, Urbana, Ill. (M. Maxwell, Office of Conferences and Institutes, Univ. of Illinois, Urbana, IL 61801; tel.: 217-333-2881.)

Sept. 18–21 Eastern Section Annual Meeting, Mohonk Mountain House, N.Y. Sponsor, Seismological Society of America. (Ellyn Schlesinger-Miller or Noel Barstow, Lamont-Doherty Geological Observatory, Palisades, NY 10964; tel.: 914-359-2900.)

Sept. 18–22 Brecciation and Mineralization International Conference, Colorado Springs, Colo. (Leanne Stone, Division of Continuing Education, Univ. of Nevada-Reno, Reno, NV 89557; tel.: 702-784-4046.)

Sept. 19–20 14th Biennial Conference Conference on Ground Water. Sponsors, University of California Water Resources Center and California Department of Water Resources. (The Water Resources Center, University of California, Davis, CA 95616; tel.: 916-752-1544.)

Sept. 18–23 International Technical Conference on National Weather Service Real-Time Data Collection and Natural Flood Hazards, Sacramento, Calif. Sponsors, WMO, NOAA, Calif. Dept. of Water Resources. (R. J. C. Burnash, Calif. Nevada River Forecast Center, National Weather Service, Room 1641, 2416 Ninth Street, Sacramento, CA 95814 or the Secretary-General, WMO, Case Postale No. 5, CH-1211 Geneva 20, Switzerland.)

Sept. 18–28 International Symposium on the Geology of the Taurus Belt, Ankara, Turkey. Sponsor, Mineral Research and Exploration Institute of Turkey and Geological Society of Turkey. (Maden Tetkik ve Arama Enstitüsü (MTA), Toros Jeolojisi Uluslararası Simpozyumu, Düzenleme Kurulu, Ankara, Turkey.)

Sept. 21–25 Technical Symposium on Acid Rain Transport and Transformation Phenomenon, Burlington, Vt. (E. A. Cassell, School of Natural Resources, 335 Aiken Center, Univ. of Vermont, Burlington, VT 05405.)

Sept. 23–24 Models in Geomorphology, Buffalo, N.Y. (Michael Woldenberg, Dept. of Geography, State Univ. of New York, Buffalo, NY 14260.)

Sept. 26–30 Second International Meeting on Statistical Climatology, Lisbon, Portugal. Sponsors, National Science Foundation, Office of Naval Research, WMO. (A. H. Murphy, Dept. of Atmospheric Sciences, Oregon State Univ., Corvallis, OR 97331.)

Sept. 30–Oct. 1 AGU Pacific Northwest Regional Meeting, Bellingham, Wash. (David E. Engebretson, FNAGU, Dept. of Geology, Western Washington State College, Bellingham, WA 98225.)

October Second Iraqi Hydrological Conference, Sponsor, IAHS. (Dr. N. Al Ansari, Ministry of Irrigation, Baghdad, Iraq.)

Oct.–Nov. 22nd Session of the UNESCO General Conference. (Sorin Dumitrescu, Director, Division of Water Sciences, UNESCO, 7, place de Fontenoy, 75700 Paris, France; tel.: 331-577-1610 x6093.)

Oct. 2–7 Penrose Conference on Cretaceous Climates, Colorado Springs, Colo. Sponsors, GSA and the International Geologic Correlation Program. (Eric Barron, National Center for Atmospheric Research, P.O. Box 3000, Boulder, CO 80307.)

Oct. 3–7 Chapman Conference on Magnetic Reconnection, Los Alamos National Laboratory, Los Alamos, N.M. (Meetings, AGU, 2000 Florida Ave., N.W., Washington, DC 20009.)

Oct. 8–12 Meeting: Association of Earth Science Editors, Houston, Tex. (Pamela Jones, Lunar and Planetary Institute, 3303 NASA Road One, Houston, TX 77058; tel.: 713-486-2150.)

Oct. 8–13 19th Annual AWRA Conference and Symposium, San Antonio, Tex. (Kenneth D. Reid, Executive Director, AWRA, 5410 Grosvenor Lane, Suite 220, Bethesda, MD 20814.)

Oct. 9–15 Sixth International Symposium on Environmental Biogeochemistry, Santa Fe, N.M. (James A. Brierley, Department of Biology, New Mexico Institute of Mining and Technology, Socorro, NM 87801.)

Oct. 11–16 Second International Symposium on River Sedimentation, Nanjing, China. (D. Gyoceu, Nanjing Hydraulic Research Institute, 223 Guangzhou Road, Nanjing 210024, Peoples Republic of China.)

Oct. 13–14 The Water Resources of Georgia and Adjacent Areas, Atlanta, Ga. Sponsors, Georgia Geologic Survey, Georgia Institute of Technology. (Bernd Kahn, Environmental Resources Center, Georgia Institute of Technology, Atlanta, GA 30332; tel.: 404-894-3776; or Ram Arora, Georgia Geologic Survey, 19 M. L. King Jr., Dr., S.W., Atlanta, GA 30334; tel.: 404-656-3214.)

Oct. 16–20 Fifth International Conference on Basement Tectonics, Cairo, Egypt. Sponsor, Denver-based Basement Tectonics Committee, Inc. (J. J. Gallagher, Jr., Cities Services Co., Box 3908, ...

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Aeronomy

0430 Composition (atomic or molecular)
AN OBSERVATIONAL STUDY OF WATER VAPOR IN THE MID-LATITUDE MESOSPHERE USING GROUND-BASED MICROWAVE TECHNIQUES

R. K. Bevilacqua (Code 4138BE, Naval Research Laboratory, Washington, D. C. 20375), J. J. Olivero, P. R. Schwartz, C. J. Gibbins, J. M. Bologna, and D. J. Thacker

Ground-based spectral line measurements of the 22.2 GHz water vapor atmospheric emission line are used to infer the atmospheric water vapor profile. The results ...

Measurements of mean sound velocities in the first, largely unlithified layers in the sea floor were made using the sonobuoy technique in several areas in the northern Indian Ocean. Older measurements were added to new measurements and regressions for mean and instantaneous velocity versus one-way travel time of sound are presented for the Central Bengal Fan, the Central Andaman Sea Basin, the Nicobar Fan, and the Sunda Trench. New data and regression equations are presented for the Mergui-North Sumatra Basin and for four forearc basins between Sumatra and Java and the Sunda Trench. Minimum velocity gradients were found in those areas where sedimentation rates were high, and sediments have accumulated in thick sections which have not had time to fully consolidate (porosity in the top of the sediment section has not been fully reduced under overburden pressure). These minimum velocity gradients (just under the sea floor) were found in the four forearc basins where they ranged from $0.34\ s^{-1}$ to $0.81\ s^{-1}$ with an average of $0.58\ s^{-1}$. The near-surface velocity gradient in the Sunda Trench was $1.33\ s^{-1}$, but was higher in the adjacent, fossil Nicobar Fan ($1.62\ s^{-1}$). In the surface of the Bengal Fan the velocity gradient was low in the upper fan ($0.86\ s^{-1}$), high in the central fan ($1.91\ s^{-1}$), and again lower in the southern fan ($1.18\ s^{-1}$), which may support sedimentation models calling for bypassing of the central fan and higher rates of accumulation on the southern fan.

J. Geophys. Res., Red, Paper 3B1251

Geochemistry

1410 Chemistry of the atmosphere
THE ROLE OF THE OCEAN IN THE GLOBAL ATMOSPHERIC SULFUR CYCLE

B.C. NGUYEN (Centre des Faibles Radioactivités, ...

Geomagnetism and Paleomagnetism

Geodesy and Gravity

Exploration Geophysics

... A simple method for application of this technique is presented. (Segregation vesicles, mid-ocean ridge basalt, magnetic polarity, structure).

J. Geophys. Res., Red, Paper 3B1161

Hydrology

3110 Erosion and Sedimentation
EROSION FROM LOW SLOPES

Calvin K. Mutchler (USDA Sedimentation Laboratory, Oxford, Mississippi, 38655), and K. C. McGregor

Simulated rainfall was used to generate erosion of plots, 22.9 meters long, on 0.1% slopes with different surface water depths. Maximum erosion rates occurred under an average surface runoff depth of about 2 mm. Erosion decreased with increasing depths greater than 2 mm; little change in erosion rates occurred for depths greater than about 10 mm. The results of this study suggest some interesting possibilities on the use of soil and water management to help control erosion of flatlands. Any tillage system such as bedding that leaves soil exposed to rainfall will result in high local erosion rates because only a very thin water layer will cover much of the soil surface. In contrast, any flow retardance that will increase surface water depths will greatly reduce erosion from the area covered. (Soil erosion, surface water depth, erosion of low slopes, mechanics of erosion).

Water Resour. Res., Paper 3W1213

3130 Groundwater (Aquifer Thermal Energy Storage)
AN ANALYSIS OF THE EFFECT OF SURFACE HEAT EXCHANGE ON THE THERMAL BEHAVIOR OF AN IDEALIZED AQUIFER THERMAL ENERGY STORAGE SYSTEM

O. Güven (Civil Engineering Department, Auburn University, Auburn, Alabama, 36849), J. G. Melville, and F. J. Molz

Analytical expressions are derived for the temperature distribution and the mean temperature of an idealized aquifer thermal energy storage (ATES) system, taking into account the heat exchange at the ground surface and the finite thickness of the overlying layer above the storage aquifer. The analytical expressions for the mean temperature may be used to obtain rough estimates of first-cycle recovery factors for preliminary evaluations of shallow confined or unconfined ATES systems. The results, which are presented in nondimensional plots, indicate that surface heat exchange may have a significant influence on the thermal behavior of shallow ATES systems. Thus, it is suggested that the effects of surface heat exchange should be considered carefully and included in the detailed analyses of such ATES systems. (Aquifer ...

... model has been verified against analytical solutions. Two real problems involving transport of a chain of three components in unfractured and fractured porous media are presented to demonstrate the accuracy and efficiency of the proposed finite element technique. Results indicate that the present numerical model is capable of producing good predictions of breakthrough curves using relatively coarse spatial and temporal ...

discretizations. A major advantage of the present transport model over previous transport models is that the latter are based on a numerical approach that employs overall discretization and simultaneous solution of the entire set of algebraic equations for concentration values in the fracture and porous matrix block domains. Such an approach is not computationally efficient, when compared with the present numerical approach, which employs not only separate discretizations of the fracture and porous matrix domains but also direct sequential solutions of much smaller subsets of algebraic equations. Another important practical aspect is that the present model enables more complex problems, involving transverse diffusion into porous matrix and two-dimensional transport in the fracture flow plane, to be handled without resorting to a fully three-dimensional grid. In practical applications, CPU time and cost involved in performing a fully three-dimensional analysis of multiple species transport may be prohibitive.
Water Resour. Res., Paper 3W1096

3130 Groundwater
THE INTERACTION OF LAKES WITH VARIABLY-SATURATED POROUS MEDIA
T. C. Winter (U.S. Geological Survey, WRD, P.O. Box 25046, MS 413, DFC, Denver, CO 80225)
Numerical simulation of variably saturated porous media indicates that ground-water recharge is variable in time and space, depending on the thickness of the unsaturated zone through which infiltrating water must move. The resulting complex, transient, ground-water flow systems have significant impact on contiguous surface water. In very permeable media, small, local, closed, ground-water flow systems can develop and dissipate within a few weeks to several months after major recharge. These have a direct effect on contiguous surface water by alternately causing seepage to and seepage from the surface water. The transient nature of these flow systems indicate reversals of the direction of ground-water flow may be common. In less permeable media, the same complex flow systems may occur, but the time for development and dissipation is much greater. For example, it is conceivable that small, local flow systems may exist for many months or years as a result of major recharge. Therefore, directions of flow in such systems are more stable, and the effect on contiguous surface water also is more stable. The findings of this study indicate that wells and ground-water quality sampling sites need to be carefully located to accurately define water-table configuration, ground-water recharge, direction of seepage through the beds of surface-water bodies, and complex geochemical processes related to changing directions of ground-water flow. (Limnology, soil moisture).
Water Resour. Res., Paper 3W1154

3130 Groundwater
POSSIBLE EFFECTS OF EROSIONAL CHANGES OF THE TOPOGRAPHIC RELIEF ON PORE PRESSURES AT DEPTH
J. Tóth (Geology Department, University of Alberta, Edmonton, Alberta, T6G 2E3, Canada), S.F. Millar
Formation-fluid pressures are said to be anomalous or abnormal if they differ from hydrostatic for the depth considered. Explanations of the origin and maintenance of anomalies seldom include the possibility of delayed adjustment of subsurface pore-pressures to erosional modifications of the topographic relief. Yet, the present paper shows that it is entirely possible for subaerial erosion to generate pore-pressure changes at great depths by cross-formational energy transfer in realistic field conditions. Conversely, pressures may survive changes in the topography and be in a transient state for hundreds to millions of years thus appearing anomalous at the time of observation. According to calculations for the Red Earth region in Alberta, Canada, present pore pressures in the Devonian immediately above the Precambrian basement at a depth of approximately 1400 meters may have been induced originally by erosionally shaped topography during Pliocene times 12 to 1 million years B.P., but be adjusting now to new boundary conditions created by the erosional exposure of the sub-Cretaceous unconformity. A 12 percent adjustment may already have taken place during the last 300 thousand years leaving nearly 90 percent of Pliocene age pressures to survive to date as slowly decaying transient pressure relicts of the geologic past. In view of the possible erosional effects on pore pressures demonstrated in this paper the question of anachronous formation pressures may deserve consideration in problems related to deep basin hydrology, including: regional groundwater resource-development; migration and accumulation of hydrocarbons; radioactive waste isolation; and dating of various geologic events. (Deep basins, cross-formational flow, relict pressures, topographic effect).
Water Resour. Res., Paper 3W1104

3160 Runoff and streamflow
INFLUENCE OF THE POINT BAR ON FLOW THROUGH CURVED CHANNELS
W.E. Dietrich (Department of Geology and Geophysics, University of California, Berkeley, California 94720), and J. Dungan Smith
In a channel with bed topography that does not vary in the downstream direction, a secondary circulation comprised of outward flow at the surface and inward flow near the bottom, extends across the entire width. If the curvature is constant, the cross-stream velocity component near the bed and the pattern of boundary shear stress can be estimated by assuming fluid accelerations to be small. Unfortunately, this procedure cannot be used in analyzing the flow through natural river meanders, or through channels with downstream constant bottom topography but with rapidly changing curvature. In these latter cases, effects arising from bed- and bank-induced momentum changes must be accounted for. Evidence for a substantial topographically-induced alteration in the cross-stream flow pattern relative to that for the analogous constant bottom topography case is provided through new analyses of several sets of laboratory and field data. Shoaling over the point bar in the upstream part of the bend is shown to force the high velocity core of the flow toward the pool. This is accomplished by a convective-acceleration caused decrease in the cross-stream water surface slope and a resulting dominance of the vertically averaged centrifugal force. The primary effect is a velocity component toward the outside or concave bank throughout the flow depth over the upstream, shallow part of the point bar and an outward component of boundary shear stress in this region. The channel curvature induced inward component of boundary shear stress consequently is confined to 20 or 30% of the channel width at the pool. Outward transfer of momentum over the point bar, as manifested by a rapid crossing of the high velocity core from the inside bank to the outside one, contributes to an enhanced decrease in boundary shear stress along the convex side of the stream as the top of the bar is approached. Forces arising from topographically-induced spatial accelerations are of the same order of magnitude as the downstream boundary shear stress and water surface slope force components, so they must be modeled as zero order, not first or second order, effects. (Secondary circulation, convective acceleration.)
Water Resour. Res., Paper 3W1080

3190 Techniques
SOME ALGORITHMS FOR PARAMETER ESTIMATION IN WATER RESOURCES SYSTEMS
O. Sehitoglu (Mechanical Engineering Department, Louisiana State University, Baton Rouge, LA 70803)
Real-time algorithms for the estimation of the unknown model parameters of some water resources systems are developed. The algorithms are of recursive form and can be used for on-line identification purposes. Specifically, proportional and proportional plus integral type algorithms are derived by applying Lyapunov's stability theorem. This approach guarantees the asymptotic convergence of the algorithm in the space of unknown parameters. The finite element method is used to discretize the spatial domain of the systems considered. The algorithms do not require prior knowledge of the unknown parameters and the system initial conditions. Numerical examples presented are the convection-diffusion equation and Burgers' equation. (Parameter estimation, algorithms, water resources systems).
Water Resour. Res., Paper 3W1097

3199 Miscellaneous (Real-time flood forecasting)
A STOCHASTIC-DYNAMIC MODEL FOR REAL-TIME FLOOD FORECASTING
[illegible], W.E. Watt (Department of Civil Engineering, Queen's University, Kingston, Ontario, Canada, K7L 3N6), and B.O. Watts
A stochastic-dynamic model for real-time flood forecasting was developed using Box-Jenkins modelling techniques. The purpose of the forecasting system is to forecast flood levels of the Saint John River at Fredericton, New Brunswick. The model consists of two submodels: an upstream model used to forecast the headpond level at the Mactaquac Dam and a downstream model to forecast the water level at Fredericton. Inputs to the system are recorded values of the water level at East Florenceville, the headpond level and gate position at Mactaquac, and the water level at Fredericton. The model was calibrated for the spring floods of 1973, 1974, 1977 and 1978, and its usefulness was verified for the 1979 flood. The forecasting results indicated that the stochastic-dynamic model produces reasonably accurate forecasts for lead times up to two days. These forecasts were then compared to those from the existing forecasting system, and were found to be as reliable as those from the existing system. (Real-time, flood forecasting, Box-Jenkins models).
Water Resour. Res., Paper 3W0446

Meteorology

3710 Boundary layer structures and processes
MODELING THE DIURNAL DEPENDENCE OF THE OPTICAL REFRACTIVE INDEX STRUCTURE PARAMETER
R. S. Kunkel (New Mexico Department of Agriculture, Las Cruces, New Mexico 88003), D. L. Walters
A model which simulates the diurnal dependence of the optical refractive index structure parameter within the atmospheric boundary layer is constructed by solving an energy balance equation for the ground surface temperature. This solution yields surface fluxes of sensible and latent heat. Empirical relationships are then used to calculate the structure parameter. Model results compare favorably with data obtained at a desert location. In particular, the model is very accurate in simulating the structure parameter during the daytime. At night, the model simulates the mean value of the structure parameter adequately. However, short-term fluctuations are simulated qualitatively but not quantitatively. This is due to the effects of drainage flows and gravity waves on nighttime turbulence structure. A sensitivity analysis indicates that the structure parameter is particularly sensitive to time of year, wind speed, the product of soil heat capacity and soil density, and soil moisture content. This model is applicable over relatively flat surfaces with little or no vegetation. (Modeling, boundary layer, turbulence).
J. Geophys. Res., Green, Paper 3C1376

3713 Chemical composition and chemical interactions (Monoterpene Hydrocarbons)
MEASUREMENT OF MONOTERPENE HYDROCARBONS AT NIWOT RIDGE, COLORADO
J. M. Roberts (NOAA/ERL Aeronomy Lab, R/E/AL6, Boulder, Colorado, 80303), F. C. Fehsenfeld, D. L. Albritton, and R. E. Sievers
Measurements of atmospheric monoterpene hydrocarbons were made at a site in the Colorado mountains. The measurements were undertaken to examine the influence of the compounds on the photochemistry of the troposphere. A sampling technique was developed using Tenax GC porous polymer with analysis by capillary gas chromatography using flame ionization and mass spectrometric detection. Positive identification of six monoterpene hydrocarbons, α-pinene, camphene, β-pinene, myrcene, Δ-3-carene, and d-limonene was obtained, as well as tentative identification of α-thujene and β-phellandrene. A definite seasonal trend was evident in the average monoterpene mixing ratios. The summertime average was 0.30 ppbv for the sum of the five major identified monoterpenes, α-pinene, β-pinene, Δ-3-carene, camphene, and d-limonene, with a high degree of constancy in relative ratios of each throughout the summer months. Two wintertime measurements gave mixing ratios below the detection limits (0.001 ppbv of an individual compound). Simultaneous measurements of ozone, NO, NO_x, and monoterpene hydrocarbons allowed examination of the contribution of monoterpene photooxidation to ozone production. Based on reported modeling studies, monoterpenes were estimated to be a small source of ozone, insufficient to account for the relatively high ozone mixing ratios (> 60 ppbv) sometimes observed at this sampling site. (Monoterpene hydrocarbons, photochemistry, ozone production).
J. Geophys. Res., Green, Paper 3C1234

3713 Chemical composition and chemical interactions
THE COMPOSITION OF WESTERN ATLANTIC PRECIPITATION USING SHIPBOARD COLLECTORS
James N. Galloway (Department of Environmental Sciences, University of Virginia, Charlottesville, Virginia 22903), Anthony H. Knap, Thomas M. Church
Techniques have been developed for the collection of rain on board ships. Chemical and meteorological analysis of rain events shows that rain can be collected (no major ions on board ships) in a contamination free manner by using collectors on the windward side of the ship. The results also support the conclusion of Jickells et al. (1982) that rain associated with North American air masses has elevated levels of $SO_4^=$, NO_3^- and H^+, while rain associated with eastern Atlantic air masses has background values.
J. Geophys. Res., Oceans, Paper 3C1304

3715 Chemical composition and chemical interaction
FORMALDEHYDE (HCHO) MEASUREMENTS IN THE NONURBAN ATMOSPHERE
D. C. Lowe and Ulrich Schmidt (Institut für Chemie 3: Atmosphärische Chemie der Kernforschungsanlage Jülich GmbH, Postfach 1913, D-5170 Jülich, F R G)
The mixing ratio of formaldehyde (HCHO) has been determined for air samples collected at a moderately polluted continental site (Jülich, FRG) and for samples collected at coastal sites in Ireland and New Zealand. In addition the HCHO mixing ratio has been determined for air samples collected in the North and South Atlantic during a cruise of the F.S. Meteor from Hamburg at 55° N to Montevideo at 35° S in October and November 1980. The HCHO mixing ratio in clean tropical marine air is of the order of 0.2 ppbv, about 50 % lower than predicted by current photochemical models, that include CH_4 oxidation as the only source for HCHO. In the mid Atlantic diurnal variations of the HCHO mixing ratio showing weak maxima during the early afternoon were occasionally observed. Those variations may be attributed to the unusual behaviour of the photochemical and physical processes which determine the mixing ratio of HCHO during stable weather conditions. The results are discussed with regard to the currently accepted theory of the photochemistry of HCHO in the clean troposphere. It appears that the yield of HCHO formation through hydrocarbon photooxidation in the background marine troposphere is less than assumed from model considerations, most probably due to the lack of sufficiently high NO concentrations. (Trace gas, marine troposphere, sampling, latitudinal profile).
J. Geophys. Res., Green, Paper 3C1208

3733 Electrical Phenomena
SIMULTANEOUS PULSES IN LIGHT AND ELECTRIC FIELD FROM STEPPED LEADERS NEAR GROUND LEVEL
W. H. Beasley (Dept. of Elec. Engr., Univ. of Florida, Gainesville, Florida, 32611), M. A. Uman, D. M. Jordan, S. Ganesh
During the summer of 1982, we used a collimated narrow slit and photomultiplier tube in conjunction with a broadband electric-field system to study light and electric-field signals from cloud-to-ground lightning flashes in Gainesville, Florida. For three flashes at a range of about 2 km, we observed correlated sequences of light and electric-field pulses from sections of channel about 12 meters long and about 60 meters above ground for 50 to 100 us prior to the first return strokes. These time intervals included all the leader light pulses that were recorded in each case. In one case there were at least nine distinct light pulses. Sometimes there were measurable electric-field pulses preceding the first light pulse. Early or intermediate light pulses were the largest in amplitude. Electric-field pulses generally increased in amplitude with time up to the return stroke. We interpret these observations as the result of leader steps passing through the field of view of the slit. Both light and electric-field pulses occurred at intervals of 3 to 20 us, had 10% to 90% risetimes of 0.3 to 0.9 us, and had full widths at half maximum of 0.6 to 1.5 us. We estimate that stepped-leader speeds within 100 meters of ground were between 0.8×10^6 and 3.9×10^6 m s^{-1}. These observations appear to be the first published records of correlated light and electric field signals from stepped leaders near ground.
J. Geophys. Res., Green, Paper 3C1141

3740 General circulation
MODIFICATION OF STRATOSPHERIC CIRCULATION BY TRACE CONSTITUENT CHANGES?
T. J. Dunkerton (Physical Dynamics, Inc., P. O. Box 3027, Bellevue, WA 98009)
The effect on the quasi-biennial oscillation of diabatic heating due to volcanic aerosols is investigated. A diabatic vertical velocity of order .2 km d^{-1}, corresponding to a localized tropical heating rate of order .1°C/day, has an effect on the QBO similar to that observed in 1963-1965. Easterly shear zones are relatively cold at the equator; their descent is retarded by the diabatic circulation. When all other factors are assumed constant, the dynamical link between Agung and the QBO requires tropical confinement of the aerosol cloud and a radiative heating rate of the correct order of magnitude. There is evidence that these requirements may have been met at least in the first two years following the Agung eruption. In this case, the effect of the Agung aerosol cloud in 1963-1965 is seen to be dynamical as well as thermodynamical, resulting in an anomalously long QBO period.
J. Geophys. Res., Green, Paper 3C1232

3799 General (Atmospheric measurements)
THE ATMOSPHERIC LIFETIME EXPERIMENT, VI: RESULTS FOR CCl_4 BASED ON THREE YEARS OF DATA
P.G. Simmonds (Geochemistry Department, University of Bristol, Bristol, U.K.), F.N. Alyea, C.A. Cardelino, A.J. Crawford, D.M. Cunnold, B.C. Lane, J.E. Lovelock, R.G. Prinn, and R.A. Rasmussen
Measurements of the atmospheric concentration of CCl_4 by electron capture-gas chromatography are reported for five coastal monitoring stations for the period July 1978-June 1981. Estimates of CCl_4 emissions to the atmosphere from known industrial sources are compared with the measured trends and the absolute values of the observed concentrations. The average global concentration of CCl_4 in the lower troposphere from July 1978-June 1981 was 110 pptv and it was increasing at 1.1 pptv/year over the period. The globally averaged atmospheric lifetime of CCl_4 calculated using an optimal estimation technique and a 9-box model of the atmosphere was 32 years.
J. Geophys. Res., Green, Paper 3C1149

Mineralogy, Petrology, and Crystal Chemistry

4210 Crystal chemistry
QUANTITATIVE STUDY OF Al-Si ORDERING IN AN ORTHOCLASE FELDSPAR USING AN ANALYTICAL TRANSMISSION ELECTRON MICROSCOPE
J. Taftø (Department of Physics, Arizona State University, Tempe, Arizona, 85287), Peter R. Buseck (Departments of Geology and Chemistry)
For certain crystal orientations and diffraction conditions, electron-induced characteristic x-ray emission produces anomalous intensities as a result of electron channeling. These intensities can be used to determine directly the chemical compositions of specific crystallographic sites within individual crystals. We have used this channeling method to determine the Al-Si ordering in gem orthoclase from Ampandrandava, Madagascar. We find that 71 atomic percent of the Al occupies the T1 site, in agreement with the values derived from standard x-ray powder diffraction data.
Am. Min., 68, 9-10

4210 Crystal Chemistry
THE CRYSTAL STRUCTURE OF $CaGeO_3$ PEROVSKITE AND THE CRYSTAL CHEMISTRY OF THE $GdFeO_3$-TYPE PEROVSKITES
Tetsuhi Sasaki (Dept. of Earth and Space Sciences, State University of New York, Stony Brook, New York 11794), Charles T. Prewitt, and Robert C. Liebermann
A single-crystal x-ray study indicates that the perovskite form of $CaGeO_3$ is orthorhombic (Pbnm), and isotypic with $GdFeO_3$, although it was previously reported as a cubic form. The cell dimensions are a = 5.2607(6) Å, b = 5.2600(10), c = 7.4432(15) and V = 205.96(6) Å^3 (Z = 4; D_{calc} = 5.17 g/cm^3). The crystal structure is close to that of $GdAlO_3$. Although the unit cell of $CaGeO_3$ is pseudocubic, the structure itself is very distorted through the tilting and distortion of the polyhedra. The oxygen polyhedra are less tilted and less distorted than other $GdFeO_3$-type perovskites. The structural deformation of the $GdFeO_3$-type perovskites is determined primarily by the size-ratio of two kinds of cation occupying A and B sites. Some structural characteristics such as O(2)-O(2)-O(2) and A-O(1)-B angles and bond-length distortions exhibit systematic relationships as a function of the observed tolerance factor which was newly defined here. A strong correlation between the Goldschmidt tolerance factor and the observed tolerance factor has made possible some predictions for $GdFeO_3$-type perovskites. (Single-crystal X-ray Study, $CaGeO_3$, Orthorhombic Perovskite, Crystal Chemistry)
Am. Min., 68, 9-10

4220 Descriptive Mineralogy
HASHEMITE, $Ba(Cr,S)O_4$, A NEW MINERAL FROM JORDAN
P. L. Hauff (U.S.G.S., P.O. Box 25046, MS 917, Denver, CO, 80225), E. E. Foord, S. Rosenblum, W. Hakki
Hashemite, $Ba(Cr,S)O_4$, from west-central Jordan is associated with chromian ettringite, apatite, and calcite in a phosphatic carbonate analogous to the Hatrurim Formation in Israel. The mineral is orthorhombic, Pnma, with a = 9.112(2) Å, b = 5.541(1) Å, c = 7.343(1) Å, Z = 4. Major diffraction lines include: 3.916(10), 3.171(6), 3.699(6), 2.179(9), 2.16(4.6), 2.77(4), 3.403(3.5), 2.001(3.5), 2.187(3), 1.711(3). It occurs as small, euhedral, dark-brown, commonly zoned crystals with an averaged $D_{(meas.)}$ = 4.50 g/cm^3 and a hardness of 3.5. Hashemite is biaxial (+); refractive indices on light and dark material are: (dark) alpha 1.852(2), beta 1.960(2), gamma 1.977(2), (light) alpha 1.810(2), beta 1.813(2), gamma 1.824(2). 2V varies from 36° to 57°. Microprobe analyses of zoned crystals yield BaO = 61.4, CrO_3 = 31.3, and SO_3 = 7.80 summing to 100.00. (Mineral, x-ray diffraction, optics, chemical analysis).
Am. Min., 68, 9-10

4299 General (Manganese Minerals)
A REVIEW OF THE TODOROKITE-BUSERITE PROBLEM: IMPLICATIONS TO THE MINERALOGY OF MARINE MANGANESE NODULES
Roger G. Burns (Department of Earth and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, Massachusetts, 02139), V. M. Burns and H. W. Stockman
The names todorokite and buserite are two competing terminologies for the abundant manganese oxide mineral occurring in deep-sea manganese nodule deposits. Proponents of the buserite phase claim it to be the parent of todorokite which is considered to be a mixture of buserite and its breakdown products birnessite and manganite (γ-MnOOH). The recent experimental evidence demonstrating the integrity of todorokite (a tekto-manganate with multidimensional tunnels formed by walls of edge-shared [MnO_6] octahedra) has led to an assessment of the proposed relationships between synthetic buserite (a phyllo-manganate containing layers of edge-shared [MnO_6] octahedra) and its transformation products. Inconsistencies are found to exist in published electron diffraction data underlying the proposed topotactic transformation mechanism of synthetic birnessite platelets to acicular "γ-MnOOH" crystallites suggested to constitute natural todorokites. The crystal chemistry of todorokite structure-types is discussed. We suggest that three types of atomic substitution occur in the tunnel structures: first, substitution of Mn^{2+} by other divalent cations (e.g. Mg^{2+}, Ni^{2+}, Co^{2+}, Zn^{2+}) in the "walls" formed by chains of edge-shared [MnO_6] octahedra, characteristically three octahedra wide; second, replacement of Mn^{4+} by similar sized cations (e.g. low-spin Co^{3+}) in the "ceilings" or "floors" typically three, but as many as seven or more, [MnO_6] octahedra wide; and third, in the tunnel interiors adjacent to Mn^{4+} vacancies in the "ceilings," a variety of large cations (K^+, Ba^{2+}, Ag^+, Pb^{2+}, Ca^{2+}, Na^+), H_2O molecules, and hydrated transition metal cations could be accommodated. We recommend that the name todorokite be universally adopted for the predominant manganese oxide mineral accommodating divalent cations of nickel and copper in marine manganiferous concretions. (Manganese nodules, todorokites, buserite, marine minerals).
Am. Min., 68, 7-8

Oceanography

4703 Boundary Layer and Exchange Processes
SEA SURFACE TEMPERATURE PATTERNS AND AIR-SEA FLUXES IN THE GERMAN BIGHT DURING MARSEN 1979, PHASE 1
K. B. Katsaros (Department of Atmospheric Sciences, University of Washington, Seattle, Washington, 98195), A. Fiuza, F. Sousa and V. Amann
An analysis was made of remotely sensed sea surface temperatures (SST) obtained from aircraft and satellite and of data from hydrological surveys conducted in the German Bight during the Marine Remote Sensing Experiment in the North Sea, August 15 to September 19, 1979. The double front associated with freshwater and mixing along the 30 m bottom contour at the northeastern edge of the submarine glacial valley of the Elbe River was the most prominent feature. Air-sea fluxes of heat and momentum were computed using parameterization schemes. The SST patterns can be grouped according to the intensity of the wind stress and of the net heat gain by the sea. The thermal signal of the front is more evident at the surface when the wind stress is greater than about 0.5 N m^{-2}. In the summer of 1979 these occasions were also associated with weak heating or with a net cooling of the sea. During periods of weaker wind stress and strong solar heating, a shallow thermocline develops which tends to isolate the frontal cold water from the interface and the SST pattern becomes less organized. Frontal eddies related to the baroclinicity and to the current shear at the frontal zone were visible in the surface distributions of density and on the satellite infrared imagery. (Sea surface temperature, remote sensing, topographic front).
J. Geophys. Res., Green, Paper 3C1181

4713 Circulation
AN EXAMPLE OF METEOROLOGICAL EFFECTS ON THE ALBORAN SEA GYRE
P. J. Ourca (Naval Ocean Research and Development Activity, Code 340 NSTL, MS 39529), T. H. Kinder
Following a period of weak winds, an AXBT (Air-deployable Expendable Bathythermograph) survey on 1-3 July 1980 showed the Alboran Sea Gyre clearly present at 100 m depth but not at the surface. Winds on 5 and 6 July were from the west at ~13 m/sec, and both AXBT temperature distributions and satellite images collected on 6 July 1980 showed the gyre clearly dominating the temperature structure both at 100 m and at the surface. The differences between the surface and 100 m temperature patterns of July demonstrates that caution must be used when interpreting satellite imagery in the Alboran Sea. Previous studies based upon satellite imagery data to represent the gyre's structure should be reviewed. The change in the shallow temperature distribution from 4 to 6 July is opposite to what some investigators have proposed as the normal response of the gyre to atmospheric forcing. (Alboran Sea, circulation, satellite imagery, Mediterranean Sea).
J. Geophys. Res., Green, Paper 3C1314

4713 Circulation
OBSERVATIONS OF A LOOP CURRENT FRONTAL EDDY INTRUSION ONTO THE WEST FLORIDA SHELF
T. Paluszkiewicz (Skidaway Institute of Oceanography, Post Office Box 13687, Savannah, Georgia 31416), L.P. Atkinson, E.S. Posmentier, and C.R. McClain
Hydrographic and satellite data from the west Florida shelf between 1-9 April 1982 showed the intrusion of a Loop Current frontal eddy onto the shelf. Data were examined to describe the structure of this feature and study effects of its intrusion on water masses in the outer shelf region. A frontal eddy, consisting of a warm filament separated from the main body of the current by a region of cooler water, propagated southeastward at 30 cm/sec intruding onto the shelf near 26°N between 4-6 April. T-S properties revealed that water in the filament was Loop Current water that had been contiguous with 80 m deeper Loop Current water in the main body of the current; water in the cold region was Continental Edge water, a transitional water mass with cooler, fresher T-S characteristics. Upwelling of deeper Loop Current water occurred under this region and elevated nutrient concentrations were found in the upwelled dome under the cold region. Interleaving occurred along water mass boundaries enabling the exchange of heat and salt. This mixing and the supply of cool, nutrient-rich water to the outer shelf were the major consequence of this Loop Current intrusion. The length scale and speed of this Loop Current frontal eddy was similar to Gulf Stream frontal eddies though the upwelling was not as intense as in observations of Gulf Stream frontal eddies. (Circulation).
J. Geophys. Res., Green, Paper 3C1315

4799 General Oceanography
FITTING OF SATELLITE AND IN-SITU OCEAN SURFACE TEMPERATURES: RESULTS FOR POLYMODE DURING THE PERIOD OF 1977-1978
George A. Maul and Nicolas J. Bravo (National Oceanic and Atmospheric Administration, Atlantic Oceanographic and Meteorological Laboratory, 4301 Rickenbacker Causeway, Miami, Florida 33149)
During the POLYMODE experiment, infrared and visible data from GOES were the only satellite data permanently archived in digital form. GOES data fitted with onboard calibration capability and were fitted, using least squares and other methods, to XBT, buoy, tide gauge, and ship of opportunity reports, to remove atmospheric effects and calibration offset. For the experiment period considered, December 1977 through February 1978, bivariate Gaussian discriminant function cloud identification showed more than 93% of the 8 km resolution GOES infrared pixels to be cloud contaminated. Cloud-free in-situ calibrated pixels were distributed in non-random groups, which resulted in systematic errors being least squares fitted. Surfaces and regression lines were least-squares fitted and the ratios were also used. Best results were obtained with 5 regression in the form of an better than 1.4 K. Due to extensive cloudiness the linear regressions were seldom useful and temperature ratios with experimental errors best represent the applicability of GOES data to sea surface temperatures. A composite of all cloud-free data for the three months left the area unobserved, but the mean surface temperature map and the standard deviation map are an improvement over ship maps due to higher spatial resolution.
J. Geophys. Res., Green, Paper 3C1343

4799 General (Hydrothermal Circulation)
INITIATION AND COLLAPSE OF ACTIVE CIRCULATION IN A HYDROTHERMAL SYSTEM AT THE MID-ATLANTIC RIDGE, 23°N.
Barbara A. Cosens (Union Oil Geothermal, Box 6854, Santa Rosa, California 95406)
Gabbro and basalt, collected from an area south of the Kane Fracture Zone along the Mid-Atlantic Ridge, have three stages of alteration which record the cooling of a hydrothermal system: 1) Stage 1. Penetration of seawater began between 400° and 510°C, altering pyroxene to fibrous green amphibole. 2) Stage 2. Propylitic alteration formed along connected fractures at 230° to 300°C. As fracture density increased, the Fe/Mg ratio of chlorite increased, the final result being an Fe-chlorite - quartz - sulfide breccia. 3) Stage 3. Late smectite veinlets formed at low temperatures (≤100°C) after active circulation ceased.
The study focuses on Stage 2 alteration. By assuming local equilibrium between alteration minerals and the hydrothermal fluid, constraints can be placed on the fluid composition responsible for Stage 2 alteration, the stage associated with deposition of sulfides. The following activities of species in solution were determined for the system $FeO-MgO-CaO-Na_2O-Al_2O_3-SiO_2-H_2O$ at 150 bars and 250°C: Log $a(Ca^{++})/a^2(H^+)=8.0$, Log $a(Na^+)/a(H^+)=5.0$, Log $a(Fe^{++})/a^2(H^+)=-7.5$, Log $a(Mg^{++})/a^2(H^+)=6.0$. Log $a(SiO_2)$ was set at quartz saturation (-2.3 at 150 bars and 250°C).
Fluid inclusions record the introduction of a low temperature, seawater-salinity fluid during formation of the latest quartz veins associated with Stage 2 alteration. Mixing of this and the hydrothermal fluid caused a drop in temperature and increase in oxidation state, resulting in increased precipitation of quartz, pyrite and chalcopyrite. The salinities of fluid inclusions trapped in quartz during Stage 2 alteration are as much as 3 times that of seawater. Concentration of a fluid initially of seawater salinity may be the result of boiling at 300°C and > 3000m depth.
J. Geophys. Res., Red, Paper 3B1350

Particles and Fields—Interplanetary Space

5510 Cosmic rays (electrons)
EARTH'S MAGNETIC FIELD AS A RADIATOR TO DETECT COSMIC RAY ELECTRONS OF ENERGY GREATER THAN A TeV
S. A. Stephens (NASA/GSFC, Greenbelt, MD 20771), and V. K. Balasubrahmanyan
We have examined the possibility of detecting electrons above a few TeV using a technique in which the electron can be unambiguously identified by the photons it emits during its traversal in the geomagnetic field. These photons would be incident nearly on a straight line on a detector; their mean energy provides a measure of the electron energy. The photon spectrum lies in the x and gamma ray region. One can make use of an omnidirectional detector to measure the energy spectrum. The collecting power of such a detector is a sensitive function of the area of the detector, the electron energy and the number of photons required to identify the electron. We have calculated the event rate expected using a balloon borne detector flown over Palestine, Texas.
J. Geophys. Res., Blue, Paper 3A1136

5510 Cosmic rays
SOLAR MODULATION OF GALACTIC COSMIC RAYS 5: TIME-DEPENDENT MODULATION
J. S. Perko (Space Science Center, University of New Hampshire, Durham, NH, 03824) and L. A. Fisk
A numerical technique is introduced for the solution of the time-dependent equation for the solar modulation of galactic cosmic rays, in which transport in heliospheric latitude is ignored. We illustrate this method with a model for the solar-cycle variation in cosmic-ray intensity. The variation is assumed to result from changes in the number of enhanced cosmic-ray scattering regions, which are produced by flare-generated shock waves in the solar wind. The model can account for the observed solar-cycle variation in intensity at different energies as well as the observed spatial gradients. This model also provides a natural explanation for the cosmic-ray hysteresis effect. (Cosmic rays, solar wind, modulation).
J. Geophys. Res., Blue, Paper 3A1319

5545 Shock Waves (Shock-Spike Events)
FORMATION OF SHOCK-SPIKE EVENTS AT QUASI-PERPENDICULAR SHOCKS
Mark E. Decker (Applied Physics Laboratory, The Johns Hopkins University, Laurel, Maryland, 20707)
This paper is an analysis of how shock-spike particle events are formed by single-encounter "shock-drift" acceleration at quasi-perpendicular, fast-mode interplanetary shocks. A set of coupled equations, valid in the upstream or downstream solar wind frames, express a particle's initial or pre-shock-interaction kinetic energy and pitch angle as functions of its final or post-shock-interaction kinetic energy and pitch angle. These equations and particular forms of the initial or ambient energy spectrum and angular distribution yield model-predicted intensity enhancements, energy spectra and pitch angle distributions for comparison with spacecraft observations. It is shown that the final energy spectrum can be harder than, softer than, or equal to the ambient spectrum, depending upon, for example, the pitch angle along the final spectrum one chooses to examine, whether one looks at the upstream or downstream spectrum, and how rapidly the ambient spectrum decreases with increasing energy. It is shown that for a given form of the ambient energy spectrum, an upstream ambient angular distribution peaked towards (away from) the shock along the magnetic field yields a final energy spectrum that is harder (softer) in both the upstream and downstream regions than the spectrum produced for an isotropic ambient distribution. The single-encounter scheme is shown to account for many features observed in the short-lived, impulsive shock-spike events. In particular, the existence of the high-intensity spike in close temporal association (~minutes) with the shock passage is consistent with a theoretical accumulation of particles accelerated and transmitted downstream of the shock. The single-encounter acceleration process is also consistent with two features of ESP events observed at radial distances of 14 - 22 AU from the sun.
J. Geophys. Res., Blue, Paper 3A1203

5540 Solar wind plasma
THE EFFECTS OF COULOMB COLLISIONS ON SOLAR WIND ION VELOCITY DISTRIBUTIONS
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The effects of Coulomb collisions on solar wind ion velocity distributions are investigated by using Helios data obtained between 0.3 and 1 AU. The mean free path of ions moving at thermal speed (in the solar wind frame) varies by three orders of magnitude in dependence on the plasma parameters. The number of collisions (roughly defined as collision frequency times the solar wind expansion time) can easily exceed one in low speed wind near the heliospheric current sheet. In these regions almost Maxwellian distributions are observed. In solar wind with intermediate speeds (ranging from 400 - 500 km/s) one usually finds distributions with a nearly isotropic core which again can be understood by the action of Coulomb collisions. On the other hand, the major part of high speed solar wind ion distributions can by good reason be called collision-less on local scales.
J. Geophys. Res., Blue, Paper 3A1310

5595 General (Wave Propagation)
MODULATIONAL INSTABILITY OF FINITE AMPLITUDE DISPERSIVE ALFVÉN WAVES
J.-I. Sakai and B.U.Ö. Sonnerup (Thayer School of Engineering, Dartmouth College, Hanover, New Hampshire 03755)
The stability of a finite amplitude plane monochromatic circularly polarized Alfvén wave is studied by use of an approximate two-fluid model obtained by performing an amplitude and dual time scale expansion in which temporal changes observed when moving with the wave are assumed slow. The lowest-order dispersive effects and coupling terms to sound waves are of the same order. A large amplitude Alfvén wave obeying an approximate dispersion relation is an exact solution of the resulting model equations. Small perturbations of this solution, consisting of two side-band Alfvén waves and a sound wave are then introduced. The resulting dispersion relation, which is of fourth order, is examined analytically for small wave amplitudes of the parent wave. It reveals different regions of stability and instability in a plot of wave number k_0 of the unperturbed wave versus β_p, the ratio of sound speed to Alfvén speed. For long wave lengths, the left-hand polarized mode is found to be stable for $\beta_p > 1$ and the right-hand polarized mode for $\beta_p < 1$. Modulational instability of the former mode occurs for $\beta_p < 1$ and of the latter for $\beta_p > 1$. Decay instability is predicted near $\beta_p = 0$ and $\beta_p = 1$. Formulas for growth rates and unstable wave number bands are given. (Modulation instability, Alfvén wave, finite amplitude).
J. Geophys. Res., Blue, Paper 3A1298

Particles and Fields—Ionosphere

3507 Particles and Fields - Ionosphere (Airglow)
RADIATION TRANSPORT EFFECTS OF THE OI 1356 Å LIMB INTENSITY PROFILE IN THE DAYGLOW
D.J. Strickland (Beers Associates, Inc., Post Office Box 2549, Reston, Virginia 22090), O.S. Anderson, Jr.
The 1356 Å dayglow limb intensity is calculated for a variety of conditions. Contributions are included from both the OI 1356 Å and N_2 LBH 1354 Å features. Photoelectron excitation rates are calculated with a recently developed computer code by Strickland and Meier (1982). OI 1356 Å multiple scattering solutions are compared with those based on the single scattering approximation and are found to be as much as a factor of 1.0 larger with the actual value changing along the profile. Multiple scattering can, therefore, not be ignored in analyses dealing with 1356 Å limb data. Solutions are generated for four sets of conditions defined in terms of solar activity and the model atmosphere. Noticeable variations occur as these conditions are altered. Excellent agreement is obtained between the theoretical intensities and limb data from the DMSP-F4 satellite UV spectrometer experiment. (Photon transport, dayglow, limb intensities).

Strickland, D.J. and R.O. Meier, A Photoelectron Model for the Rapid Computation of Atmospheric Excitation Rates, NRL Memorandum Report 5004, December, 1982.
J. Geophys. Res., Blue, Paper 3A1210

3503 Airglow
CALCULATED AND OBSERVED LIMB PROFILES OF OI(1356 Å)
A. L. Newman, A. B. Christensen (Space Sciences Laboratory, The Aerospace Corporation, P. O. Box 92957, Los Angeles, California, 90009) R. R. Anderson (Naval Research Laboratory, Washington, D.C., 20375)
Limb-scan observations of atomic oxygen OI(1356 Å) emissions obtained with the D-sensor ultraviolet spectrometer package flown on the Defense Meteorological Satellite Program (DMSP) F4 satellite are analyzed with a recently developed radiative transfer model using best current estimates for the excitation cross-sections, branching ratios, and photoelectron fluxes. The topside scale height of the limb profile depends mainly on the exospheric temperature, T_∞, used in the model computations and the peak intensity of the emission profile depends on the atomic oxygen density. To a lesser extent, the altitude of the peak and the shape of the profile vary with both T_∞ and oxygen density. It is shown that more than half of the emission originates within 19 km of the tangent point altitude along a 100 km segment of the line-of-sight. Comparison of calculated and observed profiles shows good agreement and suggests that limb-scan observations may define the altitude distribution for some thermospheric species better than empirical models alone. (Airglow, Limb-scan, oxygen, density).
J. Geophys. Res., Blue, Paper 3A1206

3507 Airglow
LARGE AMPLITUDE NIGHTGLOW OH(8-3) BAND INTENSITY AND ROTATIONAL TEMPERATURE VARIATIONS DURING A 24-HOUR PERIOD AT 78°N
H. K. Myrabø (Norwegian Defense Research Establishment, N-2007 Kjeller, Norway), C. S. Deehr and G. G. Sivjee (Geophysical Institute, University of Alaska, Fairbanks, Alaska 99701)
We report results from a continuous 24 hour measurement of the OH(8-3) band emission in the nightglow at 78.4°N. A mean temperature of 237K and a mean band intensity of 5R were observed. Extreme temperature variations were seen with amplitudes up to ± 70K from the mean. It is suggested that these variations are related to the passage of internal gravity waves. If so, the extreme amplitudes of the variations might imply that the OH emitting layer is situated above 90 km at this latitude in January. The deduced η values [ΔI/I/ΔT/T] favor the ozone mechanism to be responsible for the OH emission with the possibility of an additional mechanism contributing up to 5%. (OH airglow, intensity, temperature, gravity waves).
J. Geophys. Res., Blue, Paper 3A0690

3520 Electric fields
SPREAD F PLASMA BUBBLE VERTICAL RISE VELOCITIES DETERMINED FROM SPACED IONOSONDE OBSERVATIONS
M. A. Abdu (Instituto de Pesquisas Espaciais, Conselho Nacional de Desenvolvimento Científico e Tecnológico, 12200 São José dos Campos, SP, Brazil), R. T. de Medeiros and J. A. Bittencourt
Systematic time differences in the onsets of spread F events in the ionograms are observed between the magnetic equatorial station Fortaleza (4°S, 38°W, dip latitude 1.8°S) and the low latitude station Cachoeira Paulista (23°S, 45°W, dip latitude 15°S), two stations in Brazil, located at close by magnetic meridional planes (actually some 12° in magnetic longitude apart). On the assumption, justified from different experimental observations, that the spread F irregularities occur in strongly field aligned plasma bubbles that extend several degrees on either side of the magnetic equator, and rise up in vertically elongated columns over the magnetic equator, we have related the observed time differences in the onsets of spread F events at the two stations, to the plasma bubble vertical rise velocities over the magnetic equator. The vertical rise velocities of the plasma bubble so determined are found to be well within the values measured by VHF radar and satellite techniques, and further show, at times, good correlation with the amplitude of the prereversal peak in the vertical drift velocities and the heights of the evening equatorial F-layer. Possible implications of these results are discussed. (Plasma bubble velocity, electric field, spread F, ionosonde).
J. Geophys. Res., Blue, Paper 3A1191

5330 High-latitude ionospheric currents
COMPARISON OF HEIGHT-INTEGRATED CURRENT DENSITIES DERIVED FROM GROUND-BASED MAGNETOMETER AND ROCKET-BORNE OBSERVATIONS DURING THE PORCUPINE F3 AND F4 FLIGHTS
Ch. Ziesolleck, W. Baumjohann (MPI f. Extraterr. Physik, D-8046 Garching, W-Germany), K. Brüning, C. S. Carlson and R. J. Bush
The Porcupine F3 rocket was launched during a period of low magnetospheric activity while the F4 rocket flew during a rather disturbed interval. Measured electron spectra were used to calculate ionospheric conductances using Rees' method. Together with electric field measurements height-integrated current densities could be calculated from the rocket measurements. Height-integrated current densities at the magnetic footprint of the rockets have also been calculated from ground-based magnetometer data by means of field separation and upward continuation. A comparison of the current densities derived by the different methods shows excellent agreement in the quiet period during the F3 flight while there are differences during stronger magnetospheric activity (F4 flight) due to different spatial and temporal resolution of rocket and ground observations. (High-latitude ionospheric currents, electric fields, aurorae).
J. Geophys. Res., Blue, Paper 3A1164

3540 Ion densities and temperatures
COMPARISON OF MEASURED AND CALCULATED LOW LATITUDE IONOSPHERIC PROPERTIES
M. O. Chandler (NRC Associate, NASA/MSFC, Marshall Space Flight Center, AL 35812), R. A. Behnke, A. F. Nagy, E. G. Fontheim, P. G. Richards and D. G. Torr
Measurements of ionospheric parameters above Arecibo, Puerto Rico have been compared to a computer simulation for a variety of conditions. The simulation includes solutions to the energy, heat flow, continuity and momentum equations for O^+, H^+ and electrons. Agreement was found between the measured and calculated electron concentration during geomagnetically quiet conditions. Comparisons for more active conditions indicate a significant upward flow of ionization during the mid-afternoon. Calculated electron temperatures were found to be consistently lower than measured temperatures during the daytime. Calculated values of N_mF_2 and h_mF_2 agreed with measured results except during the post-midnight period. Calculated values of the ion flux indicate a 24 hour net flow of ionization from the northern to the southern hemisphere amounting to 12% and 6% of the equilibrium flux tube content above 1000 km for the solstice and equinox cases, respectively. (Electron temperature, modeling, incoherent scatter, ion flows).
J. Geophys. Res., Blue, Paper 3A1331

3543 Ionospheric disturbances
INFLUENCE OF SOLAR SECTOR BOUNDARIES ON IONOSPHERIC VARIABILITY
M. Mendillo (Astronomy Department, Boston University, Boston, Massachusetts, 02215) and K. Schatten
A latitudinal network of total electron content (TEC) observations has been used to assess the contributions to day-to-day F-region variability associated with a wide variety of solar-terrestrial phenomena. Recent discussions of a proposed "sun-weather coupling" effect related to solar wind boundary (SB) crossings prompted a systematic search to document any upper atmospheric component of such a linkage. TEC data from several North American sites close to the 75°W meridian (Narssarssuaq, Greenland (L = 8), Goose Bay, Labrador (L = 4), Sagamore Hill, Massachusetts (L = 3), and the Kennedy Space Center, Florida (L = 2)) were examined during the years 1973 to 1975. Average daytime (0900-1100 LT) TEC values were compared with a 27-day mean centered on the day of an SB-crossing. The resultant percentage deviations were examined for sector polarity (+ to − versus − to +) effects and for overall latitudinal patterns during a period of ± 5 days from the SB-crossings. Average results for the entire data set show peak excursions well within the ± 1σ deviations associated with day-to-day variability. There is, however, a remarkable consistency in the coherence of the small amplitude latitudinal patterns. At middle to high latitudes (L = 3-8), the TEC variations show an ordered transition from enhancements to depletions following an SB-crossing. At lower latitudes (L = 2), the opposite pattern of depletions to enhancements occurs. An identical analysis for geomagnetic activity variations (using the planetary index Ap) reveals the well-known pattern of a transition from relatively quiet to relatively disturbed activity as a sector is crossed. A merging of these two results suggests that the manifestation in the F-region of SB-crossings is nothing more than a small-scale version of the average "geomagnetic/ionospheric storm effect" that is well-documented over the L = 2-5 range. The latitudinal patterns for Δ TEC, and their seasonal variations, are consistent with the morphology of O/N_2 variations during geomagnetic disturbances and southward IMF effects during equinoctial versus solstice periods.
J. Geophys. Res., Blue, Paper 3A1175

3547 Ionospheric disturbances
BOTTOM SIDE SINUSOIDAL IRREGULARITIES IN THE EQUATORIAL F REGION
C. E. Valladares (Center for Space Sciences, University of Texas at Dallas, Richardson, TX 75080), W. B. Hanson, J. P. McClure and B. L. Cragin
A new category of equatorial F-region plasma irregularities having properties easily distinguished from those of plasma bubbles, depletions or broadband turbulence has been identified in the data from the Retarding Potential Analyzer (RPA) and the Ion Drift Meter (IDM) on the Atmosphere Explorer satellites AE-C and -E. These irregularities are observed in the bottomside at night in a narrow belt extending approximately ±12° from the dip equator, and up to 7500 km or more in the east-west direction. High resolution data from the RPA reveal nearly sinusoidal waves in the ion number density N_i with peak-to-peak $\Delta N_i/N_i$ amplitudes that span more than 3 orders of magnitude, from values less than 0.1% to more than 100%. These distinctive "Bottom Side Sinusoidal" (BSS) irregularities typically have a central wavelength lying in the range from 300 m to 3 km, and relatively narrow spectra. The power spectral index is often large (5 or 6) at the shorter wavelengths but the spectrum usually decays much less rapidly on the longer wavelength side. The vertical drift velocity also has a wavelike structure that appears to be anticorrelated to within a phase uncertainty of ±90° with the N_i variations, such that regions of lower density plasma move upward and higher density regions move downward with respect to the mean ionospheric drift. Anticorrelated wavelike drift and density fluctuations are consistent with plasma that is Rayleigh-Taylor unstable. Consideration of altitude localization and cross-field ambipolar diffusion effects can introduce at least a slight maximum in the R-T growth rate near 1 km, and also sharply limit irregularity growth at smaller scale sizes, thus providing a tentative explanation of the peaked N_i spectrum observed. Ionograms from Huancayo display a typical "altitude" frequency-spread signature when BSS is present.
J. Geophys. Res., Blue, Paper 3A1109

3570 Total Electron Content
MODELING THE TOTAL ELECTRON CONTENT OBSERVATIONS ABOVE ASCENSION ISLAND
D. N. Anderson (Air Force Geophysics Laboratory, Hanscom Air Force Base, Massachusetts 01731), J. A. Klobuchar
Recent Faraday rotation (136 MHz) measurements between Ascension Island (8°S, geog. lat.; 345°E geog. long.; 15°S dip. lat.) and the SIRIO satellite (azimuth 0°, elevation 80°) reveal two characteristic features associated with the undisturbed, ambient ionosphere - a late afternoon decrease in TEC followed by a post-sunset enhancement which lasts for two to three hours. We theoretically investigate the ambient ionosphere above Ascension Island by numerically solving the time-dependent plasma continuity equation, including the effects of ionization production by solar ultraviolet radiation, loss through charge exchange and transport by diffusion, E x B drift and neutral wind (both zonal and meridional components) appropriate for an equinoctial, solar cycle maximum period. It is found that the post-sunset enhancement in upward E x B drift, which is a characteristic feature observed by the Jicamarca incoherent scatter radar facility during solar cycle maximum periods, is primarily responsible for the post-sunset increase in TEC observations at Ascension Island between 1900 and 2300 LT. The late afternoon decrease in TEC is caused by an increase in the poleward neutral wind velocity which lowers the F layer into a higher loss rate region. Inclusion of the meridional wind not only reproduces the observed decrease but also modulates the post-sunset peak in TEC so that it is in much better agreement with the observed values. Calculated north-south asymmetries in TEC caused by a zonal wind component are also discussed. (Plasma motion and convection, tides, waves and winds)
J. Geophys. Res., Blue, Paper 3A1106

3580 Wave propagation
STIMULATED SCATTERING BY COLLISIONAL MODES IN THE IONOSPHERE
L. Stenflo (Department of Plasma Physics, Umeå University, S-901 87 Umeå, Sweden)
We point out that it ought to be possible to observe stimulated scattering by the two-stream Farley-Buneman and the gradient-drift modes in the ionosphere with, for example, the radar facilities in Northern Scandinavia. (Plasmas, nonlinear, collisions).
Rad. Sci., Paper 3S1190

3580 Wave propagation
A HYSTERESIS EFFECT IN THE GENERATION OF FIELD ALIGNED IRREGULARITIES BY A HIGH POWER RADIO WAVE
T.B. Jones (Department of Physics, University of Leicester, Leicester LE1 7RH, U.K.), T. Robinson, P. Stubbe and H. Kopka
The anomalous self absorption of a high power radio wave observed during recent ionospheric modification experiments exhibits a hysteresis effect. These results are consistent with the assumption that the growth of field aligned irregularities due to the interaction of a high power pump wave and the ionospheric plasma occurs in two stages. During the first stage, striation growth is due to an instability which has a threshold independent of striation amplitude. When the striation level is sufficiently high, the threshold of the second stage is reached. The second stage threshold is dependent on the striation amplitude. The state of background ionosphere is also found to be an important factor influencing the observed effects. (Modification, hysteresis, anomalous absorption).
Rad. Sci., Paper 3S0379

Particles and Fields—Magnetosphere

5785 Bow shock waves
A MECHANISM FOR PLASMA WAVES AT THE HARMONICS OF THE PLASMA FREQUENCY IN THE ELECTRON FORESHOCK BOUNDARY
A. J. Klimas (NASA/GSFC, Laboratory for Extraterrestrial Physics, Greenbelt, MD 20771)
A bump-on-tail unstable reduced velocity distribution has been constructed from data obtained at the upstream boundary of the electron foreshock by the GSFC electron spectrometer experiment on the ISEE-1 satellite. This distribution is used as the initial plasma state for a numerical integration of the 1-D Vlasov-Maxwell system of equations. The integration is carried through the growth of the instability, beyond its saturation, and well into the stabilized plasma regime. A power spectrum for the electric field of the stabilized plasma is computed. The spectrum is dominated by a narrow peak at the Bohm-Gross frequency of the unstable field mode but it also contains significant power at the harmonics of the Bohm-Gross frequency. The harmonic power is in sharp peaks which are split into closely spaced doublets. The fundamental peak at the Bohm-Gross frequency is also split, in this case into a closely spaced triplet. The splitting is due to slow modulation of the stabilized electric field oscillations which, it is thought, are caused by wave-particle trapping. The wave length of the m'th harmonic of the Bohm-Gross frequency is given by λ_c/m where λ_c is the wave length of the unstable mode. The mechanism for excitation of the second harmonic is shown to be second order wave-wave coupling which takes place during that period in the evolution of the instability which would otherwise be called the linear-growth phase. It is conjectured that the higher harmonics are excited by the same mechanism. It is further argued that harmonic excitation at the boundary of the electron foreshock should be a common occurrence. (Upstream waves, plasma instability, harmonics).
J. Geophys. Res., Blue, Paper 3A1103

5720 Interactions (Solar Wind)
NONLINEAR EFFECTS RELATED TO THE FORESHOCK
R. W. Jackson (Department of Electrical and Computer Engineering, University of Massachusetts, Amherst, Massachusetts, 01003)
Second order effects are calculated for a low frequency electromagnetic instability due to an ion beam in a plasma. This instability is a characteristic of a parallel shock model which includes an ion reflecting electrostatic sub-shock. The analysis is similar to that done by S. P. Gary but a counterstreaming configuration is chosen which is homogeneous in time and which has spatially growing modes. Among other effects, energy is transferred from the incoming main plasma ions to the beam ions. Electron pressure effects are calculated and are small for low frequencies. The application of this model to the earth's bow shock is discussed. (Quasilinear, spatially growing, low frequency, foreshock.)
J. Geophys. Res., Blue, Paper 3A1145

5745 Magnetospheric Configurations
LOW ENERGY PLASMA ION OBSERVATIONS IN SATURN'S MAGNETOSPHERE
Alan J. Lazarus and Ralph L. McNutt, Jr. (Department of Physics and Center for Space Research, M.I.T., Cambridge, MA 02139)
We summarize observations of positive ions in Saturn's magnetosphere made by the Voyager plasma science experiments during the two Saturn encounters. In the outer magnetosphere, the number density and temperature of the plasma is quite variable. When cold, two ionic species are clearly resolved: the lighter ion is probably H^+ and the heavier ion has a mass/charge ratio consistent with it being O^+ or N^+. In the vicinity of 18 Saturn radii (R_S), there is a region in which the composition or charge state of the ions apparently changes, but it then returns to the typical composition. The two ionic components do not have the same thermal speeds or temperatures. In the outer magnetosphere, the two components partially co-rotate with the planet; their azimuthal speeds are approximately 25% below that expected for rigid co-rotation. There is some evidence for inward and outward radial flow in addition to the azimuthal motion in approximately one-third of the Voyager 1 cold ion spectra. The sources of the plasma are still undetermined.
The plasma sheet becomes well established within 18 R_S from the planet in the Voyager 1 data and within 10 R_S in the Voyager 2 data. Near the ring plane crossings close to Saturn, O^+ is the dominant ion within 1 R_S of the ring plane, whereas H^+ dominates outside of that distance from the ring plane.
Two scale heights characterize the O^+ ion number density distribution in the vicinity of the ring plane: within 0.5 R_S of the plane, the scale height is ~.03 R_S; it is almost twice as great outside of 0.5 R_S. The directly observed temperature of the O^+ ions is too high to be consistent with such scale heights. A temperature anisotropy of $T_{perp}/T_{\parallel}$ approximately equal to 4 would explain the observations. The cause of the anisotropy is not certain.
In general, the plasma and magnetic field appear to be in dynamical equilibrium. In comparing Saturn's magnetosphere to Jupiter's, there appears to be much less acceleration of low energy plasma to higher energies at Saturn.
J. Geophys. Res., Blue, Paper 3A1231

5735 Magnetic tail
OBSERVATIONS OF ION STREAMING DURING SUBSTORMS
A. T. Y. Lui (Applied Physics Laboratory/Johns Hopkins University, Laurel, Maryland 20707), T. E. Eastman, D. J. Williams, L. A. Frank
On the basis of three-dimensional measurements of energetic particles and plasma from the ISEE-1 spacecraft, the occurrence of ion beams at the plasma sheet boundary in the magnetotail previously reported by Williams (1981) is examined in relation to substorm activity. In all seven cases studied it is found that ion beams streaming earthward and/or tailward are always present at the edge of the plasma sheet adjacent to the tail lobe. Ion beams penetrating into the plasma sheet regime with no detectable density gradient are also observed. The observed ion beams may occur at high energies of tens of keV, or at medium energies of a few keV, or even at energies as low as tens of eV. Their intensities and energies do not have any obvious relationship to the substorm onset and expansion phases or the magnitude of the substorm disturbance as indicated by the AE index. However ion beams tend to be more intense and occur at higher energies when the plasma sheet is energized during the substorm recovery phase. The result suggests that the activation of the source for the streaming ions is not directly associated with any particular phase of a substorm. (Ion beams, substorms)
J. Geophys. Res., Blue, Paper 3A1270

5755 Plasma Instabilities
ON THE ORIGIN OF PLASMASPHERIC HISS: RAY PATH INTEGRATED AMPLIFICATION
S. R. Church (Poseidon Research, 1299 Ocean Avenue, Santa Monica, California, 90401) and R. M. Thorne

A thorough investigation has been made of processes responsible for the growth, damping and propagation characteristics of whistler-mode emissions within the Earth's plasmasphere. Three dimensional ray path calculations of the integrated wave gain in a realistic model plasmasphere have provided an explicit confirmation of the anisotropic electron cyclotron resonant generation mechanism for the maintenance of plasmaspheric hiss. Peak wave amplification occurs for field aligned waves in the outer plasmasphere. The majority of unstable low frequency waves follow ray trajectories which internally reflect at the plasmapause and are thus trapped within the plasmasphere. This reflection allows waves to subsequently propagate into the locally stable inner and middle plasmasphere and also migrate substantially in longitude. The combination of internal reflection of the plasmapause and magnetospheric reflection at high latitude provide an important class of wave trajectories which are recycled back to the equatorial growth region with sufficiently small wave normal angles to allow further cyclotron resonant amplification. It is unlikely that wave growth can occur from the natural incoherent emissivity level within the plasmasphere since the required gains (≈ 100 db) would demand an unreasonably high energetic electron flux. An alternate, as yet unidentified, embryonic source is therefore required to initiate the growth process. But once established the observed spectrum of broad band plasmaspheric hiss can be maintained by the modest net gains anticipated along ray trajectories which are recycled back to the favorable equatorial growth region. A simulation of the spectral properties of waves arriving at selected observation points following several equatorial transits shows that the largest accumulated gain occurs for recycled waves which reflect from the plasmapause following each equatorial crossing. Furthermore, the peak gain is relatively insensitive to the location of the observation point, and waves are expected to arrive over a broad solid angle in t-space consistent with observations. The ability of waves to gain access to regions far from the source is a direct result of the relatively weaker Landau damping of oblique waves along the high latitude portion of the recycled ray path in comparison to the equatorial cyclotron resonant growth.

J. Geophys. Res., Blue, Paper 3A1155

5761 Plasmapause

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stress increases nearly logarithmically with increasing applied strain rate. The response to unloading depends strongly on whether or not cracks heal. Unloading that follows sealing of the cracks with mineral precipitates causes the rock to undergo a permanent non-recoverable strain.

J. Geophys. Res., Red, Paper 3B1349

6110 Physical Properties of Rocks
SLIP INSTABILITY AND STATE VARIABLE FRICTION LAWS
A. L. Ruina (Theoretical and Applied Mechanics, Cornell University, Ithaca, New York 14853)

The dependence of the friction force on slip history is described by an experimentally motivated constitutive law where the friction force is dependent on slip rate and state variables. The state variables are defined macroscopically by evolution equations for their rates of change in terms of their present values and slip rate. Experiments may strongly suggest that one state variable is adequate, or prove that one is inadequate. Analysis of steady slip governed by a single state variable in a spring and (massless) slider predicts oscillations at a critical spring stiffness $k = k_{crit}$. The critical stiffness k_{crit} is given by a simple formula and steady slip is stable for $k > k_{crit}$ and unstable for $k < k_{crit}$. State variable friction laws may superficially appear as a simple slip rate dependence, slip distance dependence, or time dependent static friction, depending on experiment and testing machinery. Truly complicated motion is possible in a spring and slider model if more than one state variable is used. Further consequences of state variable friction laws can include creep waves and apparent rate independence for some phenomena. (Friction, Stick-slip, Instability.)

J. Geophys. Res., Red, Paper 3B1216

6119 Elasticity, Fracture, and Flow
THE ROLE OF AQUEOUS FLUIDS IN THE INTERNAL FRICTION OF ROCK
J. R. Bulau, B. R. Tittmann, M. Abdel-Gawad, and C. Salvado (Materials Characterization Group, Rockwell International Science Center, Thousand Oaks, California 91360)

The effects of water on elastic energy dissipation in rock under upper crustal conditions are considered in this paper. Experimental evidence indicates that in dry rock the energy dissipation process involves water adsorbed on the surfaces of very thin cracks. In the mechanism, the adsorbed water is regarded as a viscoelastic film. Portions of this layer are forced ...

Planetology

Physical Properties of Rocks

Seismology

Social Sciences

Solar Physics, Astrophysics, and Astronomy

...

6110 Economics
THE ECONOMICS OF IRRIGATION WITH NON-UNIFORM INFILTRATION
E. Feinerman, J. Letey and H. J. Vaux, Jr. (Department of Soil and Environmental Sciences, University of California, Riverside, California, 92521)

Economic implications of non-uniform water infiltration in irrigated fields can be assessed with a simplified hydrologic balance model linked to an ...

... unit functions is exploited to reduce field survey demands and to circumvent high computation requirements. The loss function consists of a unit damage function, a unit cost function, and a unit reduction function; the degree of response that can be actually implemented is bounded by a decision constraint function. These four functions are estimated from data of various origins for seven categories of structures and three categories of decision makers.

Water Resour. Res., Paper 3W1194

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7710 Corona (Heliospheric Current Sheet)
COMPARISON OF HELIOSPHERIC CURRENT SHEET STRUCTURE OBTAINED FROM POTENTIAL MAGNETIC FIELD COMPUTATIONS AND FROM OBSERVED POLARIZATION CORONAL BRIGHTNESS
John M. Wilcox (Institute for Plasma Research, Stanford University, Stanford, California ...) and A. J. Hundhausen.

...

7720 Electromagnetic radiation
MEASUREMENTS OF THE SOLAR FLUX AT 220 nm
F. A. Hanser (Panametrics, Inc., Waltham, Massachusetts 02254) and ...

...

7110 Plages (Solar Irradiance)
SOLAR IRRADIANCE VARIATIONS. ... EXTREME ULTRAVIOLET MEASUREMENTS ON BOARD THE AE-E SATELLITE
L. Oster (National Science Foundation, Division of Astronomical Sciences, Washington, ...)

...

Tectonophysics

8110 Convection currents
...